CORNELL UNIVERSITY

OFFICIAL PUBLICATION

College of Engineering

ANNOUNCEMENT FOR

1946-1947 SESSIONS

THE UNIVERSITY CALENDAR

FALL TERM

1946		
October 11–12	*Friday, Saturday*	Registration
October 14	*Monday*	Classes begin
November 28	*Thursday*	Thanksgiving Holiday
December 21	*Saturday*	Last classes before Christmas
1947		
January 6	*Monday*	Classes resume
February 1	*Saturday*	Classes end
February 3–12	*Monday–Wednesday*	Examinations

SPRING TERM

February 14–15	*Friday, Saturday*	Registration
February 17	*Monday*	Classes begin
April 5	*Saturday*	Last classes before Spring Recess
April 14	*Monday*	Classes resume
May 31	*Saturday*	Classes end
June 2–10	*Monday, Tuesday*	Examinations

CORNELL UNIVERSITY OFFICIAL PUBLICATION

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CORNELL UNIVERSITY

OFFICIAL PUBLICATION

College of Engineering

THE SCHOOL OF CIVIL ENGINEERING

THE SIBLEY SCHOOL OF MECHANICAL ENGINEERING

THE SCHOOL OF ELECTRICAL ENGINEERING

THE SCHOOL OF CHEMICAL ENGINEERING

THE DEPARTMENT OF ENGINEERING PHYSICS

THE GRADUATE SCHOOL OF AERONAUTICAL ENGINEERING

1946 – 1947

CONTENTS

THE COLLEGE OF ENGINEERING

ITS HISTORY AND ORGANIZATION

ENGINEERING has had an important place in the program of Cornell University from the beginning. The Federal Land Grant, or Morrill Act of 1862, which supplied a considerable proportion of the University's original endowment, specified that a leading object of the institution should be to teach "such branches of learning as are related to . . . the mechanic arts"; and this provision was in perfect accord with the ideals of the founder and of the first president. Both Ezra Cornell, the practical man of affairs, who had amassed a fortune in the Western Union Telegraph Company, and Andrew D. White, the brilliant scholar and educator, who had carefully analyzed contemporary higher education in America and in Europe, believed in the equal dignity of scientific and classical studies and determined to put the practical arts, such as engineering, on the same plane with the humanities. This program was considered revolutionary when announced at the University's opening in 1868. That it has since been generally adopted by American universities indicates the soundness of the basic Cornell idea that instruction in engineering should be given on a high professional level. The College of Engineering still adheres firmly to this policy.

Mechanical engineering and civil engineering have been strong divisions of the University since its foundation. The first was originally called the College of Mechanic Arts and later the Sibley College of Mechanical Engineering and Mechanic Arts, in recognition of munificent gifts by Hiram Sibley, founder of the Western Union Telegraph Company, and his son, Hiram W. Sibley. Civil Engineering, originally a separate school in the College of Mathematics and Engineering, and later the College of Civil Engineering, has also retained its identity to the present day.

In 1883 Cornell opened courses in electrical engineering, among the first to be offered anywhere in America; and in 1919, when the Board of Trustees formed the present College of Engineering the School of Electrical Engineering was established as one of the three component units, on a par with the Sibley School of Mechanical Engineering and the School of Civil Engineering. In 1946 the Graduate School of Aeronautical Engineering was established. Also in 1946 the Department of Engineering Physics was organized with a five-year curriculum leading to the degree of Bachelor of Engineering Physics. All undergraduate curricula have now been extended to five years in order to provide the

necessary technical preparation and at the same time to include the very desirable training in nontechnical subjects.

The College of Engineering organized a five-year course in Chemical Engineering in 1931; and seven years later the School of Chemical Engineering was established to supervise the curriculum which leads to the degree of Bachelor of Chemical Engineering. Four-year courses leading to the degree of Bachelor of Science in Administrative Engineering in civil, mechanical, and electrical engineering were introduced in 1931.

Students in Engineering at Cornell use the facilities of the several Sibley buildings which house the Sibley School of Mechanical Engineering; Lincoln Hall which is devoted to the School of Civil Engineering; Franklin Hall which contains most of the School of Electrical Engineering; Rand Hall, the gift of Mrs. Florence O. R. Lang, in which are located the Machine Shop, Pattern Shop, and senior Electrical Laboratory; the Hydraulic Laboratory on Beebe Lake above Triphammer Falls; and Olin Hall of Chemical Engineering, recently given by Franklin W. Olin to provide most adequately for the School of Chemical Engineering. For various preparatory and elective courses they also use the facilities of the Baker Laboratory of Chemistry, a building given to the University in 1922 by George F. Baker; and those of Rockefeller Hall, erected by John D. Rockefeller for the Department of Physics; and other buildings and equipment available in the College of Arts and Sciences.

Cornell engineers enjoy all the benefits and privileges of an outstanding university community. They associate continually, in fraternities and dormitories, in extracurricular activities, and in general University functions, with students of liberal arts, agriculture, law, veterinary medicine, and architecture. Concerts by world-famous soloists and orchestras, lectures by renowned scholars in widely varying fields, dramatic productions, and art exhibits add to the cultural atmosphere in which Cornell engineers move as undergraduates.

These facts, in addition to the beauty of the Campus and the surrounding Finger Lakes region and the consideration that Ithaca is a small city, removed from the distractions of a metropolitan area but easily accessible by railroad and highway, help to explain the composition of the student population, which each year includes students from every part of the United States and numerous foreign countries.

The College of Engineering now comprises the School of Civil Engineering, the Sibley School of Mechanical Engineering, the School of Electrical Engineering, the School of Chemical Engineering, the Department of Engineering Physics, and the Graduate School of Aeronautical Engineering. Graduate instruction in engineering is offered by the Engineering Division of the Graduate School of the University.

PURPOSE OF THE INSTRUCTION

Engineering education at Cornell is broadly professional, designed to train men for leadership in public service, business, and industry. In the opinion of the Faculty, confirmed by representatives of concerns employing the bulk of engineering graduates, technical competence in the general field of engineering is essential to success even in the narrower specializations, such as radio, aeronautics, and air-conditioning, and time spent on fundamentals shortens the period of adjustment during which the graduate engineer discovers the specialty he is best fitted to pursue. Hence the College emphasizes instruction in the basic principles and applications of science, and offers specialized options only to a limited extent.

Experience has demonstrated that the secondary school student often lacks the ability to anticipate with accuracy the type of work for which he will ultimately find himself best adapted. Some of the largest industries, which offer the widest variety of opportunity within their own organizations, consider it necessary to observe even the engineering graduate for at least a year before deciding to what division of the company he should be assigned. Their records contain many instances of men who originally desired to become air-conditioning experts or airplane designers but eventually applied their personal aptitudes most successfully in such fields as power-plant management or metallurgical research.

Furthermore, a successful career is a record of competence in a series of situations actually available. No student can be certain that he will be offered precisely the employment that he desires at the time he graduates. Nor, in these times of rapid advances in technology, can he be sure that such a situation, if offered, would be a step along the road to the highest achievement of which he is capable. In electrical engineering, for instance, the full effect of the vacuum tube is as yet unknown, but this invention has already required not only a modification of existing electrical machines, but also an entirely new theoretical approach. Similar developments have taken place and will continue in the fields of mechanical, civil, and chemical engineering. Like the village blacksmith, the narrow specialist in engineering may one day find his specialty no longer in demand. Only a broad and intensive training in the fundamental sciences can fit an engineer to take advantage of new opportunities as progress in industry creates them.

Just as the modern engineer needs broad and deep scientific training, he also must have a working knowledge of the social and economic structure. He can no longer act as an isolated technician; he must become an effective part of the society in which he lives, able to see the results of his efforts in relation to the industrial and social system as a

whole. Unemployment, the standard of living, mass prejudices, political programs – all affect him not only as a person but also as an engineer. Such factors have constantly increasing significance in any program of public works or industrial development, and the engineer must understand them in order to solve his professional problems.

These considerations explain certain general features of the courses of study offered by the College. In all the schools, specialization has been postponed until late in the course and is limited both in character and in extent; and opportunities have been made for required and elective courses in such fields as physical science, social studies, and written and spoken English.

Dominant in all the courses of study is instruction designed to teach the fundamental principles, theoretical and practical, that underlie the various branches of engineering. Classroom instruction and laboratory experiment are supplemented by experience with the operation of various kinds of apparatus in the College laboratories and shops and by trips to inspect manufacturing plants, public works, and other places of interest in the industrial centers of the East. The student thus becomes familiar with problems encountered in modern engineering and with practical methods for their solution.

The basic purpose of the entire program is to make adjustment easier for the graduate when he begins actual engineering work, and to fit him for leadership in his profession.

DEGREES OFFERED

Cornell University confers the following degrees on the successful completion of undergraduate courses of study in the College of Engineering: Bachelor of Science in Civil Engineering (B.S. in C.E.); Bachelor of Civil Engineering (B.C.E.), Bachelor of Science in Mechanical Engineering (B.S. in M.E.), Bachelor of Mechanical Engineering (B.M.E.), Bachelor of Science in Electrical Engineering (B.S. in E.E.), Bachelor of Electrical Engineering (B.E.E.), Bachelor of Science in Administrative Engineering (B.S. in A.E.), Bachelor of Chemical Engineering (B.Chem.E.), and Bachelor of Engineering Physics.

The advanced degrees of Master of Chemical Engineering (M.Chem.E.), Master of Civil Engineering (M.C.E.), Master of Electrical Engineering (M.E.E.), Master of Mechanical Engineering (M.M.E.), Master of Science in Engineering (M.S. in Engineering), Master of Science (M.S.), Doctor of Philosophy (Ph.D.), and Master of Aeronautical Engineering (M.Aero.E.) are granted by the University on the recommendation of the Faculty of the Graduate School.

THE REQUIREMENTS FOR GRADUATION

Degrees are conferred on candidates who have fulfilled the following requirements:

1. The candidate must have been in residence and registered in the College of Engineering for the last two terms and must have satisfied the University requirements in Military Science and Tactics (or Physical Education), Physical Training, and in the payment of tuition and fees.

2. He must have completed to the satisfaction of the Faculty of the College of Engineering all the subjects, and the elective hours, prescribed in the course of study as outlined by that faculty.

3. A student who transfers to the College of Engineering, after having spent one or more terms in another college of Cornell University or elsewhere, must conform to the requirements of the class with which he graduates.

UNIVERSITY REQUIREMENTS

MILITARY SCIENCE...Cornell University requires men of the Freshmen and Sophomore classes to take the Basic Course in Military Science and Tactics. That requirement is precisely defined, and exceptions and alternatives are clearly stated, in the *General Information* booklet, which should be consulted. See also page 129 of this Announcement.

PHYSICAL TRAINING...All undergraduate men, unless officially excused, are required to follow a program of physical training, for the satisfactory completion of which one hour of credit a term will be allowed.

All undergraduate women, unless officially excused, are required to follow a program of physical education during the first four terms of their course of study. For the satisfactory completion of this requirement one hour of credit a term will be allowed.

These requirements are administered by the Dean of the University Faculty, Rockefeller Hall.

REQUIREMENTS CHANGEABLE

The College of Engineering reserves the right to modify its curricula and specific courses of instruction, to alter the requirements for admission or for graduation, and to change the degrees to be awarded, and such changes are applicable to either prospective or matriculated students at any such time as the college may determine.

GRADUATE STUDIES

Graduates of this College or of other colleges of engineering may enter the Graduate School of Cornell University and pursue advanced work in engineering. Such a student may enter either as a candidate for a degree (M.C.E., M.M.E., M.E.E., M.Chem.E., M.S. in Engineering, M.S., M.Aero.E. or Ph.D.) or without candidacy for a degree, according to the character of his previous training. A prospective graduate student should consult the *Announcement of the Graduate School* and apply to the Dean of the Graduate School. Information concerning graduate scholarships and fellowships, including the John McMullen Graduate Scholarships, can be obtained either from the Dean of the Graduate School or from the Dean of the College of Engineering.

ENGINEERING LIBRARY

This Library maintains working collections in the fields which it serves. Each year the most important new books are added to its stacks, as well as current issues of engineering journals, and transactions and proceedings of many learned societies.

The library of the Schools of Civil, Mechanical, and Electrical Engineering located in Sibley Dome includes, in addition to the regular collection, the following collections and facilities: The Kuichling Memorial Library and the support of the Irving Porter Church Fund in Civil Engineering. The Diederichs Memorial Library in Mechanical and Electrical Engineering and the James F. Lincoln Arc Welding Foundation Library in Mechanical Engineering. The Alexander Gray Memorial Library in Electrical Engineering.

The School of Chemical Engineering has the facilities of an unusually complete library in Chemistry and Chemical Engineering located in Olin Hall.

PERSONNEL AND EMPLOYMENT PROGRAM

The College of Engineering maintains a Personnel and Employment Office under the direction of the College Personnel Officer. In cooperation with this office, each school has a personnel adviser to work with the student in an appraisal of his personal characteristics and to assist him in deciding upon the type of work for which he is best suited.

Beginning with the Class of 1928, periodic surveys have been made of all graduates and a detailed record is kept of their activities since graduation. Information thus assembled is used in determining industrial and occupational trends. In cooperation with the University Placement Service, employment information is sent to those graduates who request it.

THE ENGINEERING COLLEGE COUNCIL

The Engineering College Council consists of the President of the University, the Dean of the College, and a group of distinguished engineers, usually alumni, approved by the Board of Trustees of the University. The duties of the Council are to become thoroughly acquainted with the affairs of the College, to advise the administration and the Board of Trustees with regard to policies and programs designed to increase the efficiency of the established operations, to add to the available resources, to improve public and alumni relations, or in any other way to strengthen the College's work.

MISCELLANEOUS INFORMATION

DEAN'S HONOR LIST...Students of the College of Engineering whose weighted average in their studies is 85 per cent or better are included annually in an Honor List compiled for the Dean. The honor students comprise approximately the highest tenth of all the students enrolled in the college.

STUDENTS ACTIVITIES...Students of the College of Engineering find many opportunities of engaging in wholesome activities outside their regular duties, and even outside the College, in company with members of the University generally. Within the College some find congenial occupation in helping to carry on the student branches of the national engineering societies, in conducting *The Cornell Engineer*, or in membership in national or local honor societies, which include Tau Beta Pi, Phi Kappa Phi, Sigma Xi, Chi Epsilon, Rod and Bob, Pyramid, Atmos, Kappa Tau Chi, and Eta Kappa Nu. In the University at large there are student activities of all sorts, musical, dramatic, journalistic, social, and athletic.

ENGINEERING SOCIETIES...The College of Engineering is closely associated with the Ithaca Sections of the American Society of Civil Engineers, American Society of Mechanical Engineers, and American Institute of Electrical Engineers, many of the meetings of which are held on the campus and are participated in by the members of the College. The College also maintains active student branches of these national societies as well as of the American Institute of Chemical Engineers. Their meetings are addressed by engineers of eminence, or are used for the presentation of papers by students, or for discussion, or for contests in public speaking on engineering subjects. The Schools of Mechanical and Electrical Engineering give elective credit hours for activity in the student branches of their respective engineering societies.

The Cornell Engineer, a technical journal published monthly throughout the academic year, is managed and edited by undergraduates in the College of Engineering. Elective credit is given for work on this magazine. (See page 129.)

STUDENT COUNSELORS...In each of the Schools the students have the assistance of a special corps of Class Advisers in the planning and scheduling of their academic work. Also the students are free to consult with the Dean, Directors, Department Heads, and the Instructors not only on matters pertinent to their education and future plans, but also on personal matters. In addition, the University's Counselor of Students for men and his staff may be consulted by men students regarding their non-academic problems. There is also a Counselor of Students for women.

ASSISTANCE TO FOREIGN STUDENTS...The University maintains on its staff a Counselor to Foreign Students, whose duty is to look after the welfare of all students from other countries. He may be consulted on personal problems, social questions, or any other matter in which he may be helpful. His office is in the Cornell Cosmopolitan House, 301 Bryant Avenue, which has lodging and dining room accommodations for a group of foreign and American students. It is suggested that all foreign students write him before coming to Ithaca, or call on him immediately upon arrival. He will be glad to meet foreign students at the train, help them find suitable living quarters, either at the Club or elsewhere, and introduce them to other University officials, members of the faculty, and other students.

ADMISSION

METHOD OF APPLICATION AND REQUIREMENTS FOR ADMISSION...All correspondence concerning admission to the College of Engineering should be addressed to the Director of Admissions, Cornell University, Ithaca, New York, who will forward the necessary application blanks on request.

Detailed information concerning the requirements for admission and methods of procedure are outlined in the University's *General Information* booklet, which every candidate for admission should read carefully and which can be obtained by application to the Cornell University Official Publication, 124 Roberts Place, Ithaca, New York.

SELECTIVE ADMISSION...The number of applicants admitted to the several schools of the College of Engineering is limited by the facilities available for adequate instruction. The Committee on Admissions in each of the Schools will exercise discretionary power in

selecting those to be admitted. Preference will be given to those candidates whose academic preparation and personal character indicate fitness to pursue with success the course of study to be undertaken, who show evidence of professional promise, and who complete the filing of their entrance credentials in ample time for the Admission Committee to give thorough consideration to their qualifications.

PAYMENT TO THE UNIVERSITY

TUITION AND OTHER FEES...For information concerning tuition and other fees payable to the University, see the *General Information* booklet.

FINANCIAL AID

AID FOR NEW STUDENTS...Cornell University's provision of financial help for new students of the College of Engineering consists of certain scholarships which are awarded on the basis of competition, many of them to students entering the freshman class. Prospective freshmen are eligible to compete for twenty-five University Undergraduate Scholarships, 150 State Cornell Scholarships for residents of the State of New York, and a few others, most of which are restricted to residents of certain localities. The John McMullen Regional Scholarships in Engineering are available for new students coming from outside New York State.

John McMullen Regional Scholarships are awarded annually to thirty or more selected students entering the College of Engineering. Entering male students whose preparatory work was completed at a school outside New York State and those students from New York Schools who are ineligible, at the time they enter, for the Cornell Tuition Scholarships and the State Cash Scholarships offered by the State of New York are eligible to compete. These scholarships have variable stipends up to $250 a term and may be held throughout an undergraduate course of study, provided the recipient maintains the required academic record. They were established by the Board of Trustees from a portion of the income of a munificent gift to the University by the late John McMullen of Norwalk, Connecticut, and are allotted among fifteen districts of the United States. A student is not eligible for both the State and McMullen Regional Scholarships at the same time. Application blanks and instructions are sent, about January 1 of each year, to the principals and headmasters of accredited schools for their use in recommending outstanding candidates who wish to enter the College of Engineering. An application blank will also be sent direct to the candidate upon request to the Committee on Scholarships, College of Engineering. The applications are

to be returned to the Chairman, Committee on Scholarships, before March 1. The candidates selected by the Committee for final consideration are requested to take the Scholastic Aptitude Test of the College Entrance Examination Board in April. These candidates are also interviewed by members of an alumni scholarship committee in their respective districts. Final selections are made by the Committee on Scholarships and the Dean, based upon the secondary school record, the aptitude test, and the qualities of character and general ability, as determinned by the personal interview. The successful candidates are appointed by the President of the University.

The John McMullen Industrial Scholarships in Engineering are awarded each year to four graduates of secondary schools who have spent some time in industry and have had apprentice training, preferably in a formal course given by an industrial concern. Candidates must be sponsored by responsible officers of the companies by which they have been employed. Each scholarship has a value of $250 a term and may be held throughout an undergraduate course of study provided the recipient maintains the required academic record. Inquiries should be addressed to the Chairman, Committee on Scholarships, College of Engineering, preferably not later than February, so that formal applications may be filed with the Committee on Scholarships before April 1.

For particulars of all other scholarships that are open to new students, the pamphlet on *Scholarships and Financial Aid* should be consulted. This can be obtained by application to the Cornell University Official Publication, 124 Roberts Place.

GRANTS AND OTHER AID

Students who establish superior academic records become eligible for John McMullen Regional Scholarships after one term of residence, regardless of the State in which they reside. Other scholarships, grants, and loans open to undergraduates are reserved for students who have been in residence and good standing at Cornell University for at least two terms.

Any student in the College of Engineering who needs financial aid should immediately consult the Director of his School. Ordinarily a single application is sufficient to assure consideration for all available scholarships and grants. When this is not true, the Director will instruct the student as to the proper procedure for making application. Scholarship applications for the following year received before April 1 will be given primary consideration. Late applications can be considered only for vacancies.

Certain grants are drawn from the income of special funds, the gifts

of persons who in many instances have specified to whom in general their benefits are to apply. They are not as a rule available for aid to freshmen.

Much of the financial aid which the University is able to give undergraduate students is in the form of loans from the income of endowments which are administered for the Trustees by the standing Committee on Student Aid, of which the Counselor of Students for men is Chairman. The benefits of these funds are reserved for students who have been in residence and in good standing at Cornell University for at least two terms, and preference is given to applicants of high scholastic standing who are within a year of graduation.

PRIZES

Cornell University has a considerable number of funds given for the endowment of prizes to be awarded annually. Some of these prizes are open to competition by students of the University generally. A list of them under the title *Prize Competitions,* will be mailed on request addressed to Cornell University Official Publication, 124 Roberts Place. Other prizes are open to competition particularly by students of the College of Engineering, as follows:

The Fuertes Medals, established by the late Professor E. A. Fuertes. The endowment provides for two gold medals. One is awarded annually by the Faculty to that student of the School of Civil Engineering who is found at the end of the first term of his senior year to have maintained the highest degree of scholarship in the subjects of his course, provided he has been in attendance at the University for at least two years. The other is awarded annually by the Faculty to a graduate of the School of Civil Engineering who has written a meritorious paper upon some engineering subject tending to advance the scientific or practical interests of the profession of the civil engineer. It is desired that papers be presented on or before April 15. If a paper is presented in printed form it will not be received if it has been printed earlier than the next preceding April 15. Neither medal is awarded unless it appears to the Faculty of the School of Civil Engineering that there is a candidate of sufficient merit to entitle him to such distinction.

The Fuertes Memorial Prizes in Public Speaking, founded by the late Charles H. Baker, a graduate of the School of Civil Engineering of the class of 1886. Three prizes, one of $80, one of $40, and one of $20, are offered annually to members of the junior and senior classes in the Colleges of Engineering and Architecture for proficiency in public speaking.

The Charles Lee Crandall Prizes, founded in 1916 by alumni of the

School of Civil Engineering; prizes of $75, $50, $35, and $20. They are awarded each year, by a committee appointed by the Director of the School of Civil Engineering, for the best papers written by seniors or juniors in that School on suitable subjects, provided that both the substance and the written form of the papers submitted show real merit. The prizes were established to encourage original research, to stimulate interest in matters of public concern, and to inspire in the students an appreciation of the opportunities which the profession of civil engineering offers them to serve their fellow men as intelligent and public-spirited citizens. Papers must be submitted to the Director of the School of Civil Engineering on or before May 1 of each year.

The Sibley Prizes in Mechanic Arts are offered to undergraduates in Mechanical and Electrical Engineering. Under a gift of Hiram Sibley, made in 1884, the sum of $100 is awarded annually in several prizes to juniors and seniors in the School of Mechanical Engineering and in the School of Electrical Engineering who have received the highest marks in scholarship in at least three full terms of work.

The J. G. White Prize in Spanish. Through the generosity of James Gilbert White (Ph. D., Cornell, '85) three prizes, established in 1914, each of the value of $100, are offered annually. One of the three, which is awarded to an English-speaking student for proficiency in Spanish, is open to members of the junior and senior classes in the College of Engineering who are candidates for their first degree. No candidate is eligible unless he has completed successfully two terms of work in Spanish at Cornell University.

The Robert Harris Simpson Prize, founded in 1933 by Mrs. Simpson in memory of her late husband, Robert Harris Simpson, C.E. '96. This prize of $25 is awarded annually to that senior in the School of Civil Engineering who submits the best technical description or design of a civic improvement of sufficient substance and merit to justify the award. Papers or designs must be submitted on or before December 15 of each year and are judged by a committee appointed by the Director of the School of Civil Engineering.

FACULTY AND STAFF

EDMUND EZRA DAY, Ph.D., LL.D., President of the University.
SOLOMON CADY HOLLISTER, B.S., C.E., D.Eng., Dean of the College and Professor of Civil Engineering.
WALTER L. CONWELL, C.E., Assistant Dean of the College.
ROBERT FRANKLIN CHAMBERLAIN, M.E., (in E.E.), Assistant Dean of the College and Personnel Officer.
BENJAMIN K. HOUGH, JR., B.S., M.S., Assistant to the Dean.
JEANETTE POOR, B.S., Librarian.

SCHOOL OF CIVIL ENGINEERING

WILLIAM LINDSAY MALCOLM, M.A., B.Sc., M.C.E., Ph.D., Director of the School and Professor of Civil Engineering.

EMERITUS PROFESSORS

FRED ASA BARNES, C.E., M.C.E., Professor of Railroad Engineering, Emeritus.
SAMUEL LATIMER BOOTHROYD, M.S., Professor of Astronomy, Emeritus.
HENRY SYLVESTER JACOBY, C.E., Professor of Bridge Engineering, Emeritus.
HENRY NEELY OGDEN, C.E., Professor of Sanitary Engineering, Emeritus.
JOHN THOMAS PARSON, Professor of Engineering Drawing, Emeritus.
FRANCIS JOSEPH SEERY, B.S., Professor of Hydraulic Engineering, Emeritus.

PROFESSORS

GILMORE DAVID CLARKE, B.S., Professor of Regional Planning and Dean of the College of Architecture.
JAMES NORMAN GOODIER, M.A., Ph.D., Sc.D., Professor of Mechanics.
CHARLES EDWARD O'ROURKE, C.E., Professor of Structural Engineering.
ERNEST WILLIAM SCHODER, B.S., B.S. in Min., Ph.D., World War Memorial Professor of Experimental Hydraulics.
HERBERT HENRY SCOFIELD, M.E., Professor of Testing Materials.
ROMEYN Y. THATCHER, C.E., Professor of Civil Engineering.
PAUL HALLADAY UNDERWOOD, C.E., Professor of Surveying.
CHARLES LEOPOLD WALKER, C.E., Professor of Sanitary Engineering and Secretary of the College Faculty.

ASSOCIATE PROFESSORS

DONALD J. BELCHER, B.S.C.E., M.S.E., Associate Professor of Highway Engineering.
EARLE NELSON BURROWS, C.E., M.C.E., Associate Professor of Structural Engineering.
CARL CRANDALL, C.E., Associate Professor of Civil Engineering.
DAVID E. DONLEY, B.S. in C.E., C.E., Associate Professor of Hydraulic Engineering.
HOWARD MERRILL GIFFT, B.S., M.S., C.E., Associate Professor of Civil Engineering.

ERIC VAIL HOWELL, C.E., M.C.E., Associate Professor of Mechanics.
HERBERT THEODORE JENKINS, B.S. in C.E., M.S.E., Associate Professor of Civil Engineering.
LEONARD ALEXANDER LAWRENCE, B.S. in C.E., Associate Professor of Surveying.
JOHN EDWIN PERRY, B.S. in C.E., Associate Professor of Railroad Engineering and Personnel Officer of the School of Civil Engineering.
LINCOLN REID, B.S., M.S., Associate Professor of Experimental Hydraulics.
GEORGE WINTER, C.E., Ph.D., Associate Professor of Civil Engineering.

ASSISTANT PROFESSORS

CHARLES M. ANTONI, B.S. in C.E., M.S. in C.E., Assistant Professor of Civil Engineering.
MARVIN BOGEMA, B.S., M.C.E., Assistant Professor of Civil Engineering.
LLOYD THEODORE CHENEY, B.C.E., M.S. in C.E., Assistant Professor of Civil Engineering.
HENRY EDWIN GRISET, B.S. in C.E., M.S. in C.E., Assistant Professor of Civil Engineering.
TAYLOR LEWIS, B.S. in C.E., Assistant Professor of Civil Engineering.
ROBERT MAINS, B.S. in C.E., M.S. in C.E., Assistant Professor of Civil Engineering.
MELVILLE STANTON PRIEST, B.S., M.S., Assistant Professor of Civil Engineering.
FRED J. SPRY, C.E., M.C.E., Assistant Professor of Surveying and Secretary of the School Faculty.

INSTRUCTORS

ADRIEN A. DUNCAN, B.C.E., Instructor in Civil Engineering.
JOSEPH D. GILFOYLE, B.S. in C.E., Marc Eidlitz Instructor in Civil Engineering.
MARIO LEON JUNCOSA, A.B., M.S., Instructor in Mechanics.

SIBLEY SCHOOL OF MECHANICAL ENGINEERING

W. JULIAN KING, B.Ch.E., M.E., Director of the School and Professor of Mechanical Engineering.
GEORGE RAYMOND HANSELMAN, M.E., M.S., Assistant Director of the School of Mechanical Engineering, Professor of Administrative Engineering, and Secretary of the Faculty of Mechanical Engineering.

EMERITUS PROFESSORS

CALVIN DODGE ALBERT, M.E., Professor of Machine Design, Emeritus.
WILLIAM NICHOLS BARNARD, M.E., Professor of Mechanical Engineering, Emeritus.
DEXTER SIMPSON KIMBALL, A.B., M.E., D.Sc., D.Eng., LL.D., Professor of Mechanical Engineering, Emeritus.
WILL MILLER SAWDON, B.S. in M.E., M.M.E., Professor of Experimental Engineering, Emeritus.
ALBERT EDWARD WELLS, Sibley Professor of Mechanic Arts, Emeritus.
EDGAR HARPER WOOD, M.M.E., Professor of Mechanics of Engineering, Emeritus.

PROFESSORS

PAUL HOWARD BLACK, M.E., M.S., Professor of Machine Design.
STEPHEN FARRELL CLEARY, M.E., M.M.E., Professor of Engineering Drawing.
WALTER RODNEY CORNELL, B.S., C.E., Professor of Mechanics of Engineering.
FRANK OAKES ELLENWOOD, A.B., M.E., Professor of Heat-Power Engineering.
VICTOR RAYMOND GAGE, M.M.E., Professor of Mechanical Engineering.
SEYMOUR STANTON GARRETT, C.E., World War Memorial Professor of Industrial Economics.
JAMES NORMAN GOODIER, M.A., Ph.D., Sc.D., Professor of Mechanics of Engineering.
JOSEPH OLMSTEAD JEFFREY, M.E., M.M.E., Professor of Engineering Materials.
HARRY JOHN LOBERG, M.E., M.S. in Eng., Professor of Industrial and Administrative Engineering.
CHARLES OSBORN MACKEY, M.E., Professor of Heat-Power Engineering.
JOHN ROBERT MOYNIHAN, M.E., M.M.E., Professor of Engineering Materials.
FRED STILLMAN ROGERS, B.S., M.E., Professor of Machine Design.
CLARENCE ELLSWORTH TOWNSEND, M.E., Professor of Engineering Drawing.

ASSOCIATE PROFESSORS

WILLIAM COOK ANDRAE, M.E., M.M.E., Associate Professor of Mechanical Engineering.
GEORGE FRANKLIN BUSH, B.S. in M.E., M.E., M.S. in M.E., Acting Associate Professor of Machine Design.
ROY EDWARDS CLARK, M.E., Associate Professor of Heat-Power Engineering.
BARTHOLOMEW JOSEPH CONTA, B.S. in M.E., M.S. in Eng., Associate Professor of Heat-Power Engineering.
DAVID DROPKIN, M.E., M.M.E., Ph.D., Associate Professor of Mechanical Engineering.
FREDERICK SEWARD ERDMAN, B.S., B.S. in M.E., M.M.E., Ph.D., Associate Professor of Mechanical Engineering.
HOWARD NEWTON FAIRCHILD, M.E., E.E., Associate Professor of Mechanical Engineering.
ROGER LOREN GEER, M.E., Associate Professor of Materials Processing.
WARREN HOWARD HOOK, M.E., Associate Professor of Heat-Power Engineering.
CLYDE IRA MILLARD, E.E., Associate Professor of Industrial and Engineering Administration.
WILLIAM EMERSON MORDOFF, M.E., Associate Professor of Engineering Drawing.
LOUIS LESLIE OTTO, M.E., M.M.E., Associate Professor of Mechanical Engineering.
HAROLD CHARLES PERKINS, M.E., Associate Professor of Mechanics of Engineering.
THOMAS ARTHUR RYAN, A.B., Ph.D., Associate Professor of Industrial and Administrative Engineering.
ANDREW S. SCHULTZ, JR., B.S. in A.E., Ph.D., Associate Professor of Industrial and Engineering Administration.
KENDALL C. WHITE, E.E., Associate Professor of Industrial and Administrative Engineering.

ASSISTANT PROFESSORS

THOMAS J. BAIRD, B.Arch., M.R.P., Assistant Professor in Engineering Drawing.

GERALD WAGNER EHRHART, M.E., M.M.E., Assistant Professor of Engineering Materials.
NORMAN RUSSELL GAY, B.S. in M.E., M.S. in Engineering, Assistant Professor of Heat-Power Engineering.
ROLLAND THEODORE HINKLE, B.S. in M.E., M.S., Ph.D., Assistant Professor of Machine Design.
ISRAEL KATZ, B.S. in M.E., M.M.E., Associate Professor of Mechanical Engineering.
HERMAN A. LANG, B.S. in Eng., M.S. in Eng., Assistant Professor in Mechanics of Engineering.
HAMILTON HORTH MABIE, B.S. in M.E., M.S. in Eng., Assistant Professor of Machine Design.
CLARENCE BERNARD MANSKY, B.S. in M.E., Assistant Professor in Mechanics of Engineering.
CHARLES RAYMOND OTTO, M.E., Assistant Professor in Engineering Materials.
WALTER JOSEPH PURCELL, C.E., Assistant Professor in Engineering Materials.
MARTIN WRIGHT SAMPSON, JR., B.S. in A.E., Assistant Professor of Industrial and Engineering Administration.
CHARLES RALPH SCOTT, JR., B.S. in A.E., M.S. in Eng., Assistant Professor of Industrial and Engineering Administration.
ROBERT HERMANN SIEGFRIED, M.E., Assistant Professor in Engineering Drawing.
JOHN ROBERT YOUNG, B.S. in Ch.E., M.S. in Eng., Assistant Professor of Engineering Materials.

INSTRUCTORS

HOWARD BENJAMIN CURTIS, Instructor-Technician in Materials Processing.
ANTHONY S. DISPENZA, Instructor-Technician in Gage Laboratory.
DONALD P. ECKMAN, B.S.E. (Mech.), M.S., Instructor in Mechanics of Engineering.
JOHN W. FEITNER, B.S. in M.E., Instructor in Mechanical Engineering Laboratory.
HENRY J. GIESELER, B.M.E., Instructor in Engineering Materials.
DAVID W. JOHNSON, B.M.E., Instructor in Mechanics.
WARNER LANSING, B.C.E., M.C.E., Instructor in Mechanics of Engineering.
ARTHUR J. MACK, Instructor-Technician in Materials Processing.
ROBERT CUNNINGHAM MORRIS, Instructor in Engineering Drawing.
GERHARD ADOLF NOTHMANN, B.S. in M.E., M.S. in M.E., Instructor in Machine Design.
WILLIAM FRANK PEARSON, B.M.E., Instructor in Engineering Materials.
FRANK A. SWINGLE, B.M.E., Instructor in Engineering Materials.
THOMAS B. TRACY, M.E., M.M.E., Instructor in Engineering Drawing.
ROBERT H. UNDERWOOD, B.M.E., A.B., Instructor in Mechanics.
WILLIAM W. WARD, B.M.E., Instructor in Machine Design.
EDGAR RAYMOND WATT, M.E., Instructor in Heat-Power Engineering.

FOREMEN

H. RUPERT CARPENTER
WILLARD R. KITCHEN
W. EVERETT MORGAN
ERNEST S. YAWGER

SCHOOL OF ELECTRICAL ENGINEERING

CHARLES RUSSELL BURROWS, B.S.E. (in E.E.), A.M., E.E., Ph.D., Director of the School and Professor of Electrical Engineering.

EMERITUS PROFESSOR

VLADIMIR KARAPETOFF, C.E., M.M.E., D.Sc., Professor of Electrical Engineering, Emeritus.

PROFESSORS

WILLIAM CYRUS BALLARD, JR., M.E. (in E.E.), Professor of Electrical Engineering.

LAWRENCE ADAMS BURCKMYER, JR., B.S. (in E.E.), Professor of Electrical Engineering.

ROBERT FRANKLIN CHAMBERLAIN, M.E. (in E.E.), Professor of Electrical Engineering, Personnel Officer.

TRUE McLEAN, E.E., Professor of Electrical Engineering.

MICHEL GEORGE MALTI, A.B., B.S. in E.E., M.E.E., Ph.D., Professor of Electrical Engineering.

BURDETTE KIBBE NORTHROP, M.E. (in E.E.), Professor of Electrical Engineering.

EVERETT MILTON STRONG, B.S. in E.E., Professor of Electrical Engineering.

JOSEPH G. TARBOUX, B.S. in M.E. and E.E., E.E., M.E.E., Ph.D., Professor of Electrical Engineering.

ASSOCIATE PROFESSORS

WALTER WENDELL COTNER, B.S. (in E.E.), E.E., M.E.E., Associate Professor of Electrical Engineering.

CASPER LEHMAN COTTRELL, A.B., Ph.D., Associate Professor of Electrical Engineering.

ALEXANDER BERRY CREDLE, E.E., M.E.E., Ph.D., Associate Professor of Electrical Engineering.

HENRY B. HANSTEEN, E.E., M.A., Ph.D., Associate Professor of Electrical Engineering.

WILBUR ERNEST MESERVE, B.S. (in E.E.), M.S., M.E.E., Ph.D., Associate Professor of Electrical Engineering.

HOWARD GODWIN SMITH, E.E., M.E.E., Ph.D., Associate Professor of Electrical Engineering.

STANLEY W. ZIMMERMAN, B.S. in E.E., M.S. in E.E., Associate Professor of High Voltage Laboratory.

ASSISTANT PROFESSORS

PAUL DENZIL ANKRUM, B.S. (in E.E.), A.B., Assistant Professor of Electrical Engineering.

JOHN BAIRD, B.S. in E.E., M.S. in E.E., Ph.D., Assistant Professor of Electrical Engineering.

WILLIAM H. ERICKSON, B.S. in E.E., M.S. in E.E., Assistant Professor of Electrical Engineering.

ROBERT E. OSBORNE, Assistant Professor of Electrical Engineering.

MASON MARCUS PETERSON, B.S. (in E.E.), Assistant Professor of High Voltage Practice.
STANLEY LEWRY SCHAUSS, E.E., Sc.M., Assistant Professor of Electrical Engineering.
CHARLES LOUIS SEEGER, III, B.E.E., Assistant Professor of Electrical Engineering.
JAMES HENRY SMITH, E.E., M.S. in Eng., A.B., B.S., Assistant Professor of Electrical Engineering.

INSTRUCTORS

GEORGE BECK, Instructor in Electrical Engineering.
ALFRED EMERYS DAVIES, B.S. in E.E., Instructor in Electrical Engineering.
DONALD W. HUMAN, B.E.E., Instructor in Electrical Engineering.
WALTER M. KEENAN, B.E.E., Instructor in Electrical Engineering.
MERLE J. KELLY, B.S., M.S., Instructor in Electrical Engineering.
JOSEPH CARL LOGUE, B.E.E., Instructor in Electrical Engineering.
HENRY S. McGAUGHAN, B.S.E. (Physics), Instructor in Electrical Engineering.
BENJAMIN NICHOLS, B.E.E., Instructor in Electrical Engineering.
ROBERT GEORGE PIERLOTT, JR., B.E.E., Instructor in Electrical Engineering.
LLOYD N. RAHN, B.A., M.A., Instructor in Electrical Engineering.
EDWARD H. SAWERS, B.S., M.E., Instructor in Electrical Engineering.
LAWRENCE BYRON SPENCER, E.E., Instructor in Electrical Engineering.
WILLIAM H. WILDER, B.E.E., Instructor in Electrical Engineering.

ASSISTANTS

LAVERNE ANDERSON, Assistant in Electrical Engineering.
AMIYA KUMAR CHATTERJEE, A.M.E.E., Assistant in Electrical Engineering.
WILLIAM RICHARD DAVIES, JR., Assistant in Electrical Engineering.
MOTI LAL JAIN, B.S., M.E.E., Assistant in Electrical Engineering.
ROBERT W. JOHNSTON, B.E.E., Assistant in Electrical Engineering.
ROBERT THOMAS HARNETT, Assistant in Electrical Engineering.
ROBERT BAILEY SCHULTZ, Assistant in Electrical Engineering.

SCHOOL OF CHEMICAL ENGINEERING

FRED HOFFMAN RHODES, A.B., Ph.D., Director of the School, Herbert Fisk Johnson Professor of Industrial Chemistry, Professor of Chemical Engineering, and Personnel Officer of the School.

PROFESSORS

PETER EDWARD KYLE, M.E., M.S. (in M.E.), Professor of Metallurgy.
CLYDE WALTER MASON, A.B., Ph.D., Professor of Chemical Microscopy and Metallography.
CHARLES CALVERT WINDING, B.Chem.E., Ph.D., Professor of Chemical Engineering.

ASSISTANT PROFESSORS

MALCOLM S. BURTON, B.S. in M.E., S.M. in M.E., Assistant Professor of Metallurgy.
JULIAN C. SMITH, B.S. in Chem.E., Assistant Professor of Chemical Engineering.

ROBERT L. VON BERG, B.S. in Chem.E., M.S. in Chem.E., Assistant Professor of Chemical Engineering.

ASSISTANTS

CHARLES A. N. BAKER, B.S. in Chem.E., M.S. in Chem.E., Assistant in Chemical Engineering.
GEORGE G. COCKS, B.S. in Chem.E., Assistant in Chemical Engineering.
JOHN R. CONNOLLY, B.Chem.E., Assistant in Chemical Engineering.
NORBERT J. FOECKING, B.S. in Chem.E., Assistant in Chemical Engineering.
JAMES GILLIN, Assistant in Chemical Engineering.
WILLIAM R. LEHRIAN, B.S. in Chem.E., Assistant in Chemical Engineering.
RAYMOND G. THORPE, B.S. in Chem.E., Assistant in Chemical Engineering.
ARTHUR A. VOGT, B.S. in Chem.E., Assistant in Chemical Engineering.

GRADUATE SCHOOL OF AERONAUTICAL ENGINEERING

WILLIAM R. SEARS, B.Aero.E., Ph.D., Director of the School, and Professor of Aeronautical Engineering.

ASSOCIATE PROFESSORS

ARTHUR KANTROWITZ, B.A., M.S., Associate Professor of Aeronautical Engineering.
JOHN M. WILD, B.S. in M.E., M.S. in Aero.E., Associate Professor of Aeronautical Engineering.

ASSISTANT PROFESSORS

FRED W. OCVIRK, B.S., M.S., Assistant Professor in Aeronautical Engineering.

INSTRUCTORS

FRANCOIS N. FRENKIEL, Dipl. M.E., Dr. es-Sc.
YUNG-HUAI KUO, B.S., M.A., Ph.D.

DEPARTMENT OF ENGINEERING PHYSICS

LLOYD PRESTON SMITH, Ph.D., Director of the Department and Chairman of the Department of Physics and Professor of Physics.

PROFESSORS

CHARLES RUSSELL BURROWS, Ph.D., Director of the School of Electrical Engineering and Professor of Electrical Engineering.
JACOB ROLAND COLLINS, Ph.D., Professor of Physics.
JAMES NORMAN GOODIER, M.A., Ph.D., Sc.D., Professor of Mechanics of Engineering.
GUY EVERETT GRANTHAM, Ph.D., Professor of Physics.

WILLIAM REES SEARS, Ph.D., Director of the Graduate School of Aeronautical Engineering and Professor of Aeronautical Engineering.

ASSOCIATE PROFESSORS

ALEXANDER BERRY CREDLE, Ph.D., Associate Professor of Electrical Engineering.
TREVOR RHYS CUYKENDALL, Ph.D., Associate Professor of Engineering Physics.
HENRI SAMUEL SACK, Sc.D., Associate Professor of Engineering Physics.

ASSISTANT PROFESSORS

PAUL LEON HARTMAN, Ph.D., Assistant Professor of Physics.

OTHER MEMBERS OF THE STAFF

MARIE JAMES, Secretary to the Dean.
LULU MARKELL, Clerk, Dean's Office.
ANN F. PICKARD, Secretary, Personnel and Employment Office.
MINA M. WILD, Secretary, Committee on Scholarships.
HELEN K. LIPPITT, Secretary to the Director of the School of Civil Engineering.
LILLIAN H. LEHMANN, Secretary to the Director of the Sibley School of Mechanical Engineering.
LUCY BROADHEAD, Secretary to the Director of the School of Chemical Engineering.
ELEANOR D. GEISSLER, Secretary to the Director of the School of Electrical Engineering.
KATHERINE HANDLEN, Secretary of the Electrical Engineering School.

ENGINEERING COLLEGE COUNCIL

EDMUND EZRA DAY, Ph.D., LL.D., President of the University.
SOLOMON CADY HOLLISTER, B.S., C.E., D.Eng., Dean of the College.
J. PAUL LEINROTH, M.E., Representative of Cornell Society of Engineers.
OLIVER ELLSWORTH BUCKLEY, B.S., Ph.D., Sc.D., President Bell Telephone Laboratories.
LEE H. CLARK, B.Ch.E., Vice-President in Charge of Development, Sharples Chemicals, Inc.
ALEXANDER W. DANN, C.E., Executive Vice-President, Dravo Construction Company.
HAROLD WALTER ELLEY, B.S., A.M., Ph.D., Assistant Director, DuPont Research Laboratories.
JAMES WENTWORTH PARKER, M.E., Vice-President, The Detroit Edison Company.
COLONEL FREDERICK WILLIAM SCHEIDENHELM, A.B., C.E., Consulting Engineer.
JOHN CARLTON WARD, JR., M.E., President, Fairchild Engine & Aircraft Corporation.
JOHN CROSIER WILSON, M.E., Schweitzer & Conrad, Inc.

COUNCIL OF THE ENGINEERING EXPERIMENT STATION

SOLOMON CADY HOLLISTER, B.S., C.E., D.Eng., Director of the Station and Chairman of the Council.

WILLIAM LINDSAY MALCOLM, M.A., B.Sc., M.C.E., Ph.D., in Charge of Research in Civil Engineering.

W. JULIAN KING, M.E., in Charge of Research in Mechanical Engineering.

CHARLES RUSSELL BURROWS, B.S.E. (in E.E.), A.M., E.E., Ph.D., in Charge of Research in Electrical Engineering.

FRED HOFFMAN RHODES, A.B., Ph.D., in Charge of Research in Chemical Engineering.

WILLIAM R. SEARS, B.Aero.E., Ph.D., in Charge of Research in Aeronautical Engineering.

LLOYD P. SMITH, B.S. in E.E., Ph.D., in Charge of Research in Engineering Physics.

SCHOOL OF CIVIL ENGINEERING

THE COURSES OF STUDY

The courses of study offered by the School of Civil Engineering lead to the degrees of Bachelor of Civil Engineering and Bachelor of Science in Civil Engineering. The courses are all planned to provide fundamental instruction for the practice of the profession.

The degree of Bachelor of Civil Engineering is granted to those who successfully complete the five years' work covered by the ten-term curriculum or who having been registered previous to September 1946 successfully complete the eight-term curriculum. The degree of Bachelor of Science in Civil Engineering is granted to those students who having been V–12 or NROTC students, complete the outline covered by the Navy V–12 program or its equivalent or veterans who follow the eight-term curriculum after registration September 1, 1946, or February 1947. Information on the V–12 program may be obtained from the director.

In normal times, special options in Administrative Engineering, Sanitary Engineering, Structural Engineering, Hydraulic Engineering, Transportation Engineering, Geodetic Engineering are offered. Owing, however, to the necessity of giving practically all required courses every term, it is not possible for students to take such options. Faculty action has placed all options in abeyance. Thus, until this School resumes normal operations, electives will be selected from a comparatively few specialized courses. Lists of courses that can be used as electives will be issued at the end of each term and prior to new registration.

The junior inspection trip will be held in the spring term, and the summer survey camp, replaced by special work on the campus during the emergency, will be resumed in 1947.

EQUIPMENT

The principal building occupied by the School of Civil Engineering is Lincoln Hall, containing classrooms, drafting rooms, laboratories, and the working library. The library facilities include the Kuichling Memorial Library donated and endowed by Mrs. Sarah L. Kuichling in memory of Emil Kuichling, A.B., C.E. The Irving Porter Church Fund, donated by former students of the school, aids in purchasing books.

The Highway Laboratories are housed in separate buildings and are

equipped for making the standard tests and for research in the field of highway engineering. Astronomical equipment in the Fuertes Observatory includes the instruments required for determining time, latitude, longitude, and azimuth.

A large and unusual Hydraulic Laboratory, situated at the outlet of Beebe Lake, is under the jurisdiction of this School. In addition to student instruction and research, this laboratory provides facilities for numerous important hydraulic investigations carried on in cooperation with governmental agencies and private companies.

The laboratories in Lincoln Hall are as follows: the Testing Laboratory, equipped for a wide variety of tests of cement, concrete, timber, structural steel, and other construction materials used by civil engineers; the Laboratory of Applied Elasticity, equipped for experimentation by advanced students; the Sanitary Laboratory, with facilities for physical, chemical, bacteriological, and biological analyses of water and sewage; and the Soil Mechanics Laboratory, with all the facilities for performing standard tests on soil. Further investigations in soil mechanics may be carried on cooperatively by the School staff and the Army Engineers in another laboratory housed in a separate building constructed on the Campus by the Federal Government.

OUTLINE OF THE INSTRUCTION

The object of the instruction in this School is to impart knowledge of the fundamental principles of design, construction, and operation of structures and works of the civil engineering type, in addition to providing a liberal opportunity for study of general and cultural subjects. Emphasis is placed upon civil engineering as an applied science rather than as a vocational technique.

Civil Engineering students follow the first year with as thorough a preparation as possible in the following subjects: the survey, design, construction, and operation of buildings, roads, railroads, canals, sewers, and water works; the construction of foundations under water and on land, and of superstructures and tunnels; the survey, improvement, and protection of coasts, and the regulation of rivers, harbors, and lakes; the astronomical determination of geographical coordinates for geodetic and other purposes; the application of mechanics, graphical statics, and descriptive geometry to the construction of the various kinds of arches, girders, roofs, trusses, suspension and cantilever bridges; the drainage of districts, sewerage of towns, and irrigation and reclaiming of land; the applications and tests of hydraulic and electric motors; the preparation of drawings, plans, specifications, and the proper inspection and tests of the materials used in construction. Instruction is given in engineering economy, finance, and jurisprudence.

The latter subject deals principally with the fundamental principles of the law of contracts. Opportunity is also given to seniors to specialize to a limited extent, or to broaden their training, by the election of certain courses, some of which may be chosen from approved courses in any department of the University.

The instruction in mathematics, chemistry, physics, geology, economics, psychology, and English is given in the College of Arts and Sciences. All other regular subjects are taught in the School of Civil Engineering, the School of Mechanical Engineering, or the School of Electrical Engineering.

SCHOLASTIC REQUIREMENTS

A student in the School of Civil Engineering who does not receive a passing grade in every course in which he is registered, or fails in any term or summer session to maintain an average of 65 per cent or better, with at least half the credit hours with marks of 70 per cent or better, may be dropped from the University or placed on probation.

FIVE-YEAR CURRICULUM (B.C.E.)

REGULAR COURSE

All students except veterans entering fall 1946, and thereafter

		CREDIT HOURS	CONTACT HRS. LEC. REC.	CONTACT HRS. LAB. COMP.
TERM 1	Mathematics 60a	3	3	0
	Physics 15	3	3	2½
	Chemistry 102a or 104a	3	3	2½
	English 2a	3	3	0
	Drawing 2001	3	0	7½
	Surveying 2101	3	1	5
	Total	18		
TERM 2	Mathematics 60b	3	3	0
	Physics 16	3	3	2½
	Chemistry 102b or 104b	3	3	2½
	English 2b	3	3	0
	Drawing 2002	3	0	7½
	Surveying 2102	3	3	0
	Total	18		

In addition to these courses, all Freshmen must satisfy the University's requirements in Military Science and Tactics and Physical Training.

		CREDIT HOURS	CREDIT HRS. LEC. REC.	LAB. COMP.
TERM 3	Mathematics 60c	3	3	0
	Physics 17	3	3	2½
	History 70a	3	3	0
	Route Surveying 2601 (or Construction Methods 2901)	3	1	5
	Geology 501 (or Drawing 2003)	3	2	5
	Mechanics 1131	3	3	0
	Total	18		
TERM 4	Physics 18	3	3	2½
	History 70b	3	3	0
	Construction Methods 2901 (or Route Surveying 2601)	3	3	0
	Mechanics 1132	3	2	2½
	Mechanics 1133	3	2	2½
	Drawing 2003 (or Geology 501)	3	0	7½
	Total	18		

In addition to these courses, all Sophomores must satisfy the University's requirements in Military Science and Tactics and Physical Training.

	Summer Survey Camp 2103	5		
TERM 5	Mechanics 1134	3	2	2½
	Materials 1211	3	3	0
	Fluid Mechanics 2301	3	3	0
	Applied Hydrology 2401 (or Accounting 3231)	2	2	0
	Statistics 3241 (or Accounting 3231)	2	2	2½
	Economics 3 (or Public Speaking I)	3	3	0
	Sanitary Engineering 2501	3	3	0
	Total	19		
TERM 6	Mathematics 2205	3	3	0
	Materials 1212	3	0	5
	Stress Analysis 2701	3	2	2½
	Hydraulics 2302	3	2	2½
	Public Speaking I (or Economics 3)	3	3	0
	Accounting 3231 (or 2401 and 3241)	3	2	2½
	Total	18		
TERM 7	Structural Design 2702	3	0	7½
	Materials 1213 (or 2725)	3	3	0
	Concrete Construction 2715 (or 2903)	3	0	6
	Timber Design 2703	2	0	5
	Transportation 2612 (or 2503)	3	3	0
	Water Supply and Treatment 2502 (or 2902)	3	2	2½
	Total	17		

		CREDIT HOURS	CREDIT HRS. LEC. REC.	CREDIT HRS. LAB. COMP.
TERM 8	Soil Mechanics 2725 (or 1213)	3	2	2½
	Highway Engineering 2610	3	2	2½
	Sewerage and Sewage Treatment 2503 (or 2612)	3	2	2½
	Engineering Law 2902 (or 2502)	3	3	0
	Economics of Engineering 2903 (or 2715)	3	3	0
	Electives	3		
	Total	18		
TERM 9	Advanced Stress Analysis 2704 (or 2904)	3	3	0
	Electrical Equipment 4920	3	2	3
	Highway Engineering 2611	3	3	0
	Foundations 2720 (or 2402)	3	3	0
	Money, Currency, and Banking Ec. 11 (or 41)	3	3	0
	Electives	3		
	Total	18		
TERM 10	Heat-Power Engineering 3543	3	2	2½
	Hydraulic Engineering 2402 (or 2720)	3	3	0
	Labor Conditions and Problems Ec. 41 (or 11)	3	3	0
	Public Administration 2904 (or 2704)	3	3	0
	Electives	6		
	Total	18		

Total—185 hours, including camp

FOUR-YEAR CURRICULUM (B.S. IN C.E.)

For those *veterans* of World War II who commence their work in October 1946 or February 1947.

TERM 1	Mathematics 55a	5	5	0
	Physics 11	4	4	2½
	Chemistry 102a or 104a	3	3	3
	Drawing 2001	3	0	7½
	Surveying 2101	3		5
	Total	18		
TERM 2	Mathematics 55b	5	5	0
	Physics 12	4	4	2½
	Chemistry 102b or 104b	3	3	3
	Drawing 2051	3	0	7½
	Surveying 2102	3	3	0
	Total	18		

		CREDIT HOURS	CREDIT HRS. LEC. REC.	LAB. COMP.
TERM 3	Public Speaking I (or English 2a)	3	3	0
	Engineering Geology 501 (or Surveying 2601)	2	2	5
	Drawing 2002	3	0	6
	Mechanics 1136, 1137	6	5	2½
	Construction Methods 2901 (or Economics 3)	3	3	0
	Total	18		
TERM 4	English 2a (or Public Speaking I)	3	3	0
	Route Surveying 2601 (or Engineering Geology 501)	3	1	5
	Field Astronomy 182	2	1	2½
	Drawing 2052	2	0	5
	Mechanics 1138, 1139	5	4	2½
	Economics 3 (or Construction Methods 2901)	3	3	0
	Total	18		
	Summer Survey Camp 2103	5		
TERM 5	Materials 1225 (or Soil Mechanics 2725)	3	3	0
	Materials Laboratory 1226 (or Elective)	3	0	5
	Hydraulics 2351	4	3	2½
	Structural Analysis 2701	4	3	2½
	Concrete Construction 2715 (or Elective)	3	0	6
	Total	17		
TERM 6	Structural Design 2702	3	0	7½
	Soil Mechanics 2725 (or Materials 1225)	3	2	2½
	Water Supply and Treatment 2502	3	2	2½
	Sewerage and Sewage Treatment 2503	3	2	2½
	Elective (or Concrete Construction 2715 and Materials Lab. 1226)	6		
	Total	18		
TERM 7	Electrical Equipment 4920	3	2	2½
	Engineering Management 2903 (or Engineering Law 2902)	3	3	0
	Foundations 2720 (or 2610)	3	3	0
	Engineering Problems 2255 (or 2401)	2	0	5
	Electives	6		
	Total	17		
TERM 8	Heat-Power Engineering 3543	3	2	2
	Applied Hydrology 2401 (or 2255)	2	2	0
	Highway Engineering 2610 (or 2720)	3	2	2½
	Engineering Law 2902 (or Engineering Management 2903)	3	3	0
	Electives	6		
	Total	17		

Grand total for eight terms and summer camp—146

FOUR-YEAR CURRICULUM (B.C.E.)

For those students who commenced their curricula prior to fall term 1946.

		CREDIT HOURS	CONTACT HRS. LEC. REC.	LAB. COMP.
TERM 1	Mathematics 55a	5	5	0
	Physics 11	4	4	2½
	Chemistry 102a or 104a	3	3	3
	Drawing 2001	3	0	7½
	Surveying 2101	3	1	5
	Total	19		
TERM 2	Mathematics 55b	5	5	0
	Physics 12	4	4	2½
	Chemistry 102b or 104b	3	3	3
	Drawing 2051	3	0	7½
	Surveying 2151	3	3	0
	Total	17		

In addition to taking the above courses, all Freshmen must satisfy the University's requirements in Physical Training and in Military Science and Tactics.

TERM 3	Public Speaking I	3	3	0
	Engineering Geology 501	3	2	5
	Drawing 2002	3	0	6
	Mechanics 1136, 1137	6	5	2½
	Route Surveying 2601 (or English 2a)	3	1	5
	Total	18		
TERM 4	English 2a (or Surveying 2601)	3	3	0
	Field Astronomy 182	2	2	0
	Drawing 2052	2	0	5
	Mechanics 1138, 1139	5	4	2½
	Construction Methods 2901	3	3	0
	Economics 3	3	3	0
	Total	18		

In addition to these courses, all Sophomores must satisfy the University's requirements in Military Science and Tactics and Physical Training.

TERM 5	Surveying 2152 (or Concrete Construction 2715)	3	1	5
	Materials 1225	3	3	0
	Materials Laboratory 1226	3	0	5
	Hydraulics 2351	4	3	2½
	Structural Analysis 2751	4	3	2½
	Total	17		

		CREDIT HOURS	CONTACT HRS. LEC. REC.	LAB. COMP.
TERM 6	Structural Design 2702	3	0	7½
	Soil Mechanics 2725	3	2	2½
	Treatment of Water 2502	3	2	2½
	Sewerage and Sewage Treatment 2503	3	2	2½
	Concrete Construction 2715 (or Surveying 2152)	3	0	6
	Elective	3		
	Total	18		
TERM 7	Electrical Equipment 4920	3	2	2½
	Engineering Management 2903	3	3	0
	Highway Engineering 2610	3	2	2½
	Engineering Law 2902	3	3	0
	Electives	6		
	Total	18		
TERM 8	Heat-Power Equipment 3543	3	2	2½
	Applied Hydrology 2401	2	2	0
	Foundations 2720	3	3	0
	Engineering Problems 1141	2	0	5
	Electives	6		
	Total	16		

Grand total for eight terms.....141 academic hours
(not including Military Science and Tactics and Physical Training)

SIBLEY SCHOOL OF MECHANICAL ENGINEERING

EQUIPMENT

The Sibley School of Mechanical Engineering, named in recognition of important gifts made by Hiram Sibley and his son, Hiram W. Sibley, occupies a group of buildings at the north end of the campus. In addition to the Sibley Buildings, this group includes Rand Hall, which was added through the generosity of Mrs. Florence O. R. Lang as a memorial to Jasper R. Rand, Addison C. Rand, and Jasper R. Rand, jr. The school is provided with a central working library in Sibley Dome and many of the departments also maintain special working and reference libraries.

Numerous laboratories and shops are available for carrying on the many activities of the School of Mechanical Engineering, as follows: the Materials Testing Laboratory, Heat Treatment Laboratory, and Metallography Laboratory, for determination of the physical properties of engineering materials under different kinds of stress and heat treatment; the Photo-elasticity Laboratory, for instruction and research in photoelastic work; the Steam Laboratory, for instruction and research involving steam power; the Internal-Combustion Engine Laboratory, for work with this type of power equipment; the M.E. Hydraulics Laboratory, a pump-operated laboratory for hydraulic problems; the Lubrication Laboratory, for determination of the physical properties of lubricants; the Refrigeration Laboratory, for the study of refrigeration; the Fuel Testing Laboratory, for determination of the composition and calorific value of all types of fuel; the Foundry Sand Laboratory for determining the properties of various mixtures of sands and binders under the temperatures and pressures existing in foundry molds; the Micro-Motion Laboratory, for motion and time study; the Constant-Temperature Room, and the Heat Transfer, Heating, Ventilating, Air Conditioning Laboratories; a series of Research Laboratories; the Materials Processing Laboratories—the Woodworking and Pattern Shop, the Machine Shop; the Laboratory Boiler House; and the University Heating Plant and Power House.

OUTLINE OF THE INSTRUCTION

The object of the instruction in this School is to lay as broad and substantial a foundation of general and technical knowledge and pro-

vide as much experience in engineering practice in the fields of Mechanical Engineering and Administrative Engineering as can be well imparted in a school.

Students of Mechanical Engineering are instructed primarily in the utilization of nature's sources of energy and materials for the benefit of mankind, through the development and application of prime movers, machinery, and processes of manufacture; thus, they have to do mainly with things dynamic. The province of the mechanical engineer includes the design, construction, operation, and testing of steam engines, steam turbines, steam generating apparatus, and power plant auxiliaries, internal combustion engines, hydraulic machines, pumping engines, railway equipment, compressed-air machines, ice making and refrigerating machinery, equipment for heating and ventilating and air conditioning, machine tools, mill equipment, and transmission machinery. The work of the mechanical engineer further includes the planning of power plants and factories, the selection and installation of their equipment, the development of systems of operation and manufacturing processes, and the organization and administration of plants and industries. In addition the mechanical engineer may engage in scientific research in the innumerable branches of this field.

Based upon the fundamental instruction given in the first two terms in mathematics, physics, chemistry, drawing, and materials processing, and that given in the next two terms in advanced physics, mechanics of engineering, advanced applied mathematics, materials of construction, kinematics, drawing, materials processing, machine construction, and industrial organization and management, the student in the fifth and sixth terms receives training in fluid mechanics (including hydraulics), machine design, economic organization, industrial accounting and cost finding, heat-power engineering, electrical engineering, and the testing of engineering materials. In the final terms, the student receives training in steam power-plant engineering, internal combustion engines, refrigeration and air conditioning, and mechanical engineering laboratory practice; also provision is normally made for some degree of specialization in one of the recognized fields of mechanical engineering.

To provide for this specialization, selected groups of courses, designated as Options, have been offered in the past in Power Plant Engineering, Heat Engineering (including fluid flow, heat transmission, refrigeration, and air-conditioning engineering), Industrial Engineering, Automotive Engineering, Aeronautical Engineering, Advanced Mechanics of Engineering, Metallurgical Engineering, Mechanical Engineering Design, or in other fields allied to Mechanical Engineering; also opportunity was afforded to elect various other courses of an advanced nature. Under present circumstances, however, it is necessary to discontinue temporarily these Options, as such, although many of

the courses in them are still available for election. As soon as conditions permit, the Options will be re-established; thus it is hoped that new matriculates and present lowerclassmen will find them again available when they are ready to take them.

The student in Administrative Engineering, in the field of Mechanical Engineering, pursues a curriculum which is basically one in Mechanical Engineering, but modified sufficiently to permit the incorporation of courses relating to business and industrial management.

EMPLOYMENT AFTER GRADUATION

Graduates in Mechanical Engineering find employment in the design, construction, testing and operation of prime movers and other machinery, and of complete plants in their own and related fields, and in sales engineering and industrial research and development. They serve also as planners of new projects and processes, and as aeronautical engineers, air-conditioning engineers, automotive engineers, design engineers, fuel and combustion engineers, industrial engineers, power-plant engineers, refrigeration engineers, research engineers, and teachers of engineering—to mention only a few of the many special fields open to them. With the instruction in liberal subjects and those related to administration and management coupled with the technical training, they have special qualifications to develop into leaders in their chosen field.

SCHOLASTIC REQUIREMENTS

A student in the School of Mechanical Engineering who does not receive a passing grade in every course in which he is registered, or fails in any term or summer session to maintain an average of 65 per cent or better, with at least half the credit hours with marks of 70 per cent or better, may be dropped from the University or placed on probation.

CURRICULA

Students entering direct from secondary schools, without having served in the armed forces of any of the allied nations, are to pursue the five-year curriculum leading to the degree of Bachelor of Mechanical Engineering.

A former undergraduate student of Sibley School returning from war service to renew his studies may continue in his original four-year curriculum in Mechanical or Administrative Engineering, with such minor modifications as become necessary.

Veterans matriculating for the first time prior to the fall of 1947 may pursue the four-year curriculum which leads to the degree of B.S.

in Mechanical Engineering or, instead, may elect to follow the five-year curriculum. The freshman year is the same in both the shorter and longer programs. Beginning with the fall of 1947 all new students will follow the five-year program.

FIVE-YEAR CURRICULUM IN MECHANICAL ENGINEERING (B.M.E.)

The 5-year curriculum in Mechanical Engineering is arranged to provide not only stronger technical instruction than is contained in the usual 4-year curriculum, but also to include additional training to develop leadership in this field. Accordingly, supplementing the technical courses, instruction is given in subjects related to management. Also because of the flexibility of the program, the student has an opportunity to elect other courses, liberal or otherwise, and to undertake some specialization of particular interest to him.

In his last year, the student will undertake an option consisting of a combination of advanced courses and a project in a technical, managerial, or related field for the purpose of applying to one or more broad basic problems the fundamental concepts he has been taught in the preceding years, and for the purpose of developing in him the ability to do work of an original nature.

COURSES IN FIVE-YEAR CURRICULUM

(Courses with asterisks (*) may be postponed until a later term if authorized by the student's adviser.)

			CONTACT HRS.	
		CREDIT HOURS	LEC. REC.	LAB. COMP.
TERM 1	English 2a	3	3	0
	Analytic Geometry and Calculus 60a	3	3	0
	Physics 15	3	3	2½
	Chemistry 102a or 104a	3	3	3
	Descriptive Geometry and Drafting 3111	3	1	5
	Metal Working 6111	1	0	2½
	Fundamentals of Machine Tools 3403	1	0	2½
		17		
TERM 2	English 2b	3	3	0
	Analytic Geometry and Calculus 60b	3	3	0
	Physics 16	3	3	2½
	Chemistry 102b or 104b	3	3	3
	Descriptive Geometry and Drafting 3112	3	1	5
	Casting Processes (either term) 6112	1	0	2½
	Pattern Making 3401	1	0	2½
		17		

In addition to taking the previously mentioned courses, all Freshmen must satisfy the University requirements in Physical Training and in Military Science and Tactics.

The courses in English, Mathematics, Physics, and Chemistry are given in the College of Arts and Sciences. All other courses, except Military Science and Tactics and Physical Training, are given in the College of Engineering.

		CREDIT HOURS	CONTACT HRS. LEC. REC.	LAB. COMP.
TERM 3	Analytics and Calculus 60c	3	3	0
	Physics 17	3	3	2½
	Engineering Chemistry, Organic 5761	2	2	0
	*Corporate & Industrial Organization 3235	3	3	0
	Modern History 70a	3	3	0
	*Public Speaking (either term)	2	2	0
	Economics (either term)	3	3	0
		19		
TERM 4	Mechanics 1151	3	3	0
	Physics 18	3	3	2½
	Engineering Chemistry (Physical) 5762	2	2	0
	Kinematics 3351	3	2	2½
	*Cost Accounting 3250	4	2	5
	Modern History 70b	3	3	0
		18		

In addition, all sophomores must satisfy the University requirements in Physical Training and in Military Science and Tactics.

TERM 5	Mechanics and Strength of Materials 1152	3	3	0
	Eng. Materials, Lecture-Recitations 1121	3	3	0
	Dynamics of Machinery 3352	3	2	2½
	Electrical Engineering 4931	3	2	2½
	*Hydraulics (either term) 2331	3	2	2½
	Applied Mathematics (either term) 1114	3	3	3
		18		
TERM 6	Mechanics and Strength of Materials 1153	3	3	0
	Eng. Materials, Lecture-Recitations 1122	3	3	0
	Engineering Materials Laboratory 1231	3	1	2½
	Electrical Engineering 4932	3	2	2½
	Production Machine Tools 3404	2	0	5
	Gage Laboratory 3405	1	0	2½
	Psychology (either term) 40	3	3	0
		18		
TERM 7	Advanced Mechanics & Strength of Materials 1154	3	3	0
	Machine Design 3353	3	3	0
	Engineering Materials Laboratory 1232	3	1	2½
	Heat-Power Engineering 3535	3	3	0
	*Materials Processing 6113	3	2	2½
	Electrical Engineering 4933	3	2	2½
		18		

		CREDIT HOURS	CONTACT HRS. LEC. REC.	LAB. COMP.
TERM 8	Machine Design 3354	3	1	5
	Heat-Power Engineering 3536	3	3	0
	Mechanical Laboratory 3601	3	0	5
	Electrical Engineering 4934	3	2	2½
	*Industrial Engineering 3261	3	1	5
	*Law (or Elective)	3	3	0
		18		
TERM 9	Internal Combustion Engines 3581	3	3	0
	Mechanical Engineering Laboratory 3602	3	0	5
	Project (see page 39)	3		
	Courses related to project	3		
	Elective courses	6		
		18		
TERM 10	Steam Power Plants 3582	3	3	0
	Mechanical Engineering Laboratory 3603	3	0	5
	Project (see page 39)	3		
	Courses related to project	3		
	Elective courses	6		
	Non-Resident Lecture	1	1	0
		19		
	Grand total for 10 terms			180

FIFTH-YEAR PROJECTS

In his last year, the student will undertake an option consisting of a combination of advanced courses and a project in technical, managerial, or related field for the purpose of applying to one or more broad basic problems the fundamental concepts he has been taught in the preceding years, and for the purpose of developing in him the ability to do work of an original nature.

The project may be in any one of many branches, such as, management, industrial engineering, heat-power engineering, internal combustion engines, heat engineering, heating, ventilating and air conditioning, refrigeration engineering, automotive engineering, aeronautical engineering, mechanical design, advanced mechanics and strength of materials, metallurgical engineering, engineering materials, experimental engineering, materials processing, tool engineering, welding engineering, structural engineering, physics, electrical engineering, and other fields related to mechanical engineering.

The choice of projects may be made by the student, subject to the advice and approval of his adviser and to the availability of necessary

facilities and staff for its supervision; or if the student has no choice, he may be assigned a project. In order to acquire before the fifth year the preparation needed for some types of projects, it may be necessary to postpone until later terms some courses indicated by asterisks (*) in the outline of the curriculum and to substitute a sequence of preparatory courses; however, the adjustments of the program are to be subject to the advice and approval of the student's adviser.

INDUSTRIAL & ENGINEERING ADMINISTRATION OPTION

The elective hours available in the five-year curriculum will permit a student to select an option in the field of industrial and engineering administration. For the student who is interested in this area of study an integrated program of basic courses including Industrial Statistics, Labor Relations, Production Engineering, Industrial Marketing, Production Management, Methods Engineering, and Standard Costs is available. Having completed his basic work, the student will elect six hours of work related to his major interest, such as production, quality control for inspection, accounting, sales management, personnel, labor relations, industrial design, or teaching. The combination of basic courses and elective courses in a specialized field will be followed by a 6-hour project course in his last term. The project course will serve as a capstone to integrate all the training he has had in the previous nine terms.

In order to develop the proper sequence of course material, the student interested in this field must make his choice at the beginning of his third year. This will permit him to take all the work in proper order. In those cases where a specialized interest has been definitely established, some modification in the basic courses may be made to permit the student to take those courses which more completely meet his needs. This allows the student some latitude in the selection of his courses under the guidance of the faculty so as to obtain from the various courses offered throughout the University a coordinated program of study in his chosen field.

TEMPORARY FOUR-YEAR CURRICULUM (B.S. IN M.E.)

War veterans who matriculate as freshmen prior to the fall of 1947 and who do not wish to conform to the five-year curriculum, may pursue the following four-year program, the successful completion of which leads to the degree of Bachelor of Science in Mechanical Engineering.

		CREDIT HOURS	CONTACT HRS. LEC. REC.	LAB. COMP.
TERM 1	Same as Term 1 of the 5-year curriculum (page 37)			
TERM 2	Same as Term 2 of the 5-year curriculum (page 37)			
TERM 3	Analytics and Calculus 60c	3	3	0
	Physics 17	3	3	2½
	Engineering Chemistry, Organic 5761	2	2	0
	Corporate & Industrial Organization 3235	3	3	0
	Public Speaking (either term)	2	2	0
	Economics, Ec. 3 (either term)	3	3	0
	Psychology (either term) 40	3	3	0
		19		

In addition, third-term students must satisfy the University requirements in Physical Training and Military Science and Tactics.

TERM 4	Mechanics 1151	3	3	0
	Physics 18	3	3	2½
	Engineering Chemistry, Physical 5762	2	2	0
	Kinematics 3351	3	3	2½
	Cost Accounting 3201	4	2	5
	Production Machine Tools 3404	2	0	5
	Gage Laboratory 3405	1	0	2½
		18		

In addition, fourth-term students must satisfy the University requirements in Physical Training and Military Science and Tactics.

TERM 5	Mechanics and Strength of Materials 1152	3	3	0
	Heat-Power Engineering 3535	3	3	0
	Engineering Materials, Lecture: Recitation 1221	3	3	0
	Dynamics of Machinery 3352	3	2	2½
	Electrical Engineering 4931	3	2	2½
	Hydraulics (either term) 2331	3	2	2½
	Electives	2		
		20		
TERM 6	Mechanics and Strength of Materials 1153	3	3	0
	Heat-Power Engineering 3536	3	3	0
	Engineering Materials, Lecture: Recitation	3	3	0
	Engineering Materials Laboratory 1131	3	1	2½
	Electrical Engineering 4932	3	2	2½
	Electives	1		
	Applied Mathematics (either term) 1114	3	3	0
		19		

		CREDIT HOURS	CONTACT HRS. LEC. REC.	LAB. COMP.
TERM 7	Advanced Mechanics and Strength of Materials 1154	3	3	0
	Machine Design 3353, 3354	3	3	0
	Engineering Materials Laboratory 1232	3	1	2½
	Internal Combustion Engines 3581	3	3	0
	Mechanical Engineering Laboratory 3640	3	0	5
	Electrical Engineering 4933	3	2	2½
		18		
TERM 8	Machine Design 3353, 3354	3	1	5
	Steam-Power Plants 3582	3	3	0
	Mechanical Engineering Laboratory 3642	3	1	2½
	Industrial Engineering 3261	3	1	5
	Materials Processing 6113	3	2	2½
	Electrical Engineering 4934	3	2	2½
		18		
	Grand total for eight terms	146		

CONTINUING FOUR-YEAR CURRICULUM IN MECHANICAL ENGINEERING (B.S. IN M.E.)

Former Cornell students in Mechanical Engineering may continue in a four-year curriculum conforming substantially to that which they originally pursued. Some slight modifications, however, are, or may become necessary to meet changing conditions, but they will not alter the general content of the program. The principal differences lie in the substitution of equivalent courses from the five-year curriculum and in the renumbering of former courses that are continued. (The new numbering system is explained on page 92).

SCHOOL OF ELECTRICAL ENGINEERING

THE CURRICULUM

The curriculum leading to the Degree of Bachelor of Electrical Engineering is now extended from four to five years as outlined below. This becomes necessary to permit restoration in the curriculum of a reasonable amount of non-technical and elective study which the pressure of expanding technical requirements has nearly eliminated. A considerable amount of managerial study previously offered in the curriculum leading to a degree in administrative engineering is now included.

The curriculum provides a solid foundation of basic study with considerable breadth and depth, and sufficient specialization to exercise special interests. Beginning with the eighth term, more selection of study is provided by a choice of one of several technical options. This permits the student in the last three terms to choose from among several broad branches of the profession in which he may continue his fundamental study. Within these options are found the various popular specialties such as radar, television, radio, servomechanisms, or lightning phenomena which often initiate the student's interest in electrical engineering.

OPTIONS

The curriculum in Electrical Engineering provides specifically for six options: Power Utilization, Power Generation and Transmission, Industrial Electronics, Illumination, Radio and Communication, and Physics.

The Power Utilization option concerns motors, their characteristics, control and application; servomechanisms; the electrical aspects of transportation by land, water, and air; and the use of electrical energy in industry, commerce, and the home.

The Power Generation and Transmission option deals with electric power station equipment, transmission and distribution systems, protective equipment, and high voltage practice.

The Industrial Electronics option deals with the theory and application of equipment utilizing the principles of electron emission, of control of electron flow in vacuum, and of ion and electron flow in gases. It concerns electronic control and instrumentation with low as well as high frequency equipment.

The Illumination option provides for the study of the generation and utilization of light. This field offers unique opportunities for the student with considerable breadth of interest. The option is adapted to those with interest and ability in art, dramatics, and the physiology and psychology of vision, as well as in the rigorous engineering and economic aspects of the field.

The Radio and Communication option concerns all forms of intelligence transmission by means of electricity. It includes the study of telephone and telegraph equipment, telemetering, television, sound recording and reproducing, radio transmission and equipment, as well as a study of the more recent high frequency developments, such as radar.

The Physics option provides the student with the opportunity to secure a fundamental group of courses in physics to supplement his more formal electrical engineering work, and to prepare for a career in research and advanced development in electrical engineering. This option includes such subjects as electrostatic and electromagnetic fields and waves, atomic and nuclear physics and is open only to students who demonstrate unquestionable aptitude in science.

ELECTIVES

The Electrical Engineering curriculum provides for a considerable number of elective hours. Some of these are unrestricted, some are confined to non-technical or managerial courses and others are confined to a technical group in the chosen option. Each option has a specified number of hours designated as "Project." The project in any option is chosen by the student according to his particular interests. It usually will comprise a problem in one of the option subjects although other subjects related to electrical engineering may be exploited, and any proportioning of theoretical and experimental work suited to the project is permissible.

Within the curriculum leading to the B.E.E. degree it is possible for the student to exercise considerable latitude of selection according to his interests. The new curriculum provides elective hours for other than technical study. Opportunity for contact with the broader phases of education afforded by the University has far-reaching potentiality in shaping the future life interests of the student.

THE FRESHMAN YEAR

The curriculum of the Freshman year in Electrical Engineering is essentially the same as that in Mechanical Engineering and Engineering Physics so that transfer of a student between these three curricula may occur before the third term without loss of time. The Freshman

curricula in the Schools of Chemical and Civil Engineering differ somewhat from the curriculum in Electrical Engineering so that a change to or from these schools can seldom be made without an adjustment involving additional credit hours of study to complete the curriculum.

CLASS ADVISERS

Each entering class in Electrical Engineering is assigned an experienced member of the faculty qualified as Class Adviser. He operates with the class, usually until graduation, to supervise and counsel each student regarding curriculum, registration, scholarship, and all matters concerning his academic program. Both by personal contact and by a detailed knowledge of each student's scholastic performance it becomes possible for the Class Adviser to be of considerable service to the individual student throughout his college program.

Because responsibility for the registration of each student is vested in the Class Adviser, it is especially important that no cancellation of courses or other changes in program be initiated without the adviser's knowledge and approval. Should the Class Adviser in his judgment be unable to authorize a registration or change in program desired by the student, the latter may appeal his case by petition to the School of Electrical Engineering.

SCHOLASTIC REQUIREMENTS

A student in the School of Electrical Engineering who does not receive a passing grade in every course for which he is registered, or who fails in any term or Summer Session to maintain an average grade of 70 per cent may be dropped or placed on probation.

FOUR-YEAR CURRICULUM

During the next few years of transition to the five-year curriculum provision is made for those students who expect to enter the University before September 1947, or who have matriculated at some earlier date, to pursue a four-year curriculum. This curriculum is open also to students transferring to the College of Engineering from other institutions provided they can meet the requirements for the B. S. in E. E. degree by February 1950.

FIVE-YEAR CURRICULUM

Beginning in September 1946 no four-year curriculum in engineering will be open to students entering directly from high school. The five-year curriculm leading to the degree of Bachelor of Electrical Engineering (B.E.E.) is outlined on pages 46–48. Before completing the

seventh term of the curriculum, the student, counselling with his Class Adviser, chooses one of the six options delineated beyond the seventh term.

The courses designated by four digit numbers are offered by the College of Engineering. The first digit represents the School or Department. Descriptions of courses will be found in the sections of this announcement as follows:

1. General Engineering
2. Civil Engineering
3. Mechanical Engineering
4. Electrical Engineering
5. Chemical Engineering
6. Metallurgical Engineering
7. Aeronautical Engineering

The description of required courses in the curriculum, given outside of the College of Engineering, are described on pages 129 to 135.

FIVE-YEAR CURRICULUM (B.E.E.)

		CREDIT HOURS	LEC. REC. HOURS	LAB. COMP. HOURS
TERM 1	Analytic Geometry and Calculus, Math 60a	3	3	0
	General Physics, Physics 15	3	3	3
	General Chemistry, Chemistry 102a, or Chemistry 104a	3	2	3
	Descriptive Geometry 3111	3	1	6
	Metal Working, Engineering 6111	1	0	3
	Casting Processes, Engineering 6112	1	0	3
	English 2a	3	3	0
	Total	17		
TERM 2	Analytic Geometry and Calculus, Math. 60b	3	3	0
	General Physics, Physics 16	3	3	3
	General Chemistry, Chemistry 102b or Chemistry 104b	3	2	3
	Mechanical Drafting 3112	3	1	6
	Machine Tool Processes 3402	2	0	6
	English 2b	3	3	0
	Total	17		

In addition to taking the above courses, freshmen are required to take Military Science and Tactics and Physical Training.

		CREDIT HOURS	LEC. REC. HOURS	LAB. COMP. HOURS
TERM 3	Analytic Geometry and Calculus, Math 60c	3	3	0
	General Physics, Physics 17	3	3	3
	Engineering Chemistry—Organic 5761	2	2	0
	Kinematics 3327	2	2	0
	Surveying 2131	1	0	3
	Public Speaking I	3	3	0
	Economics 3	3	3	0
	Total	17		
TERM 4	Engineering Mathematics 4031	3	3	0
	Basic Electrical Engineering 4111	4	3	3
	General Physics, Physics 18	3	3	3
	Engineering Chemistry—Physical 5762	2	2	0
	Mechanics 1125	3	3	0
	Accounting 3256	3	2	3
	Total	18		

In addition to taking the above courses, sophomores are required to take Military Science and Tactics and Physical Training.

TERM 5	Alternating Current Circuits 4112	4	3	3
	Electric Circuit Laboratory 4116	3	1	3
	Direct Current Machinery 4211	3	2	3
	Engineering Materials 1223	3	3	0
	Mechanics 1126	3	3	0
	Psychology 40	3	3	0
	Total	19		
TERM 6	Strength of Materials 1127	3	3	0
	Fluid Mechanics 2331	3	3	0
	Electron Tubes and Circuits 4121	3	3	0
	Electronics Laboratory 4126	2	0	6
	Electronic Equipment Shop 4128	1	0	3
	Electrical Machinery Laboratory 4216	4	2	3
	Alternating Current Machinery 4221	3	2	3
	Total	19		
TERM 7	Electronic Circuit Elements 4122	4	2	6
	Basic Communication Systems 4131	2	1	3
	Electrical Machinery Laboratory 4226	4	2	3
	Differential Equations, Math 200	3	3	0
	Thermodynamics 3530	3	3	0
	Modern Economic History, History 70a or (Physics 123)*	3	3	0
	Total	19		

*Students admitted to the Physics Option will take Physics 123 in Term 7, deferring History 70a to Term 9 or 10.

POWER UTILIZATION OPTION

		CREDIT HOURS	LEC. REC. HOURS	LAB. COMP. HOURS
TERM 8	Advanced Circuit Analysis 4311	3	2	3
	Machine Theory 4321	2	2	0
	Low Frequency Heating and Industrial Distribution System 4351	3	2	3
	Modern Physics, Physics 44	3	3	0
	Heat Power, Lecture 3531	2	2	0
	Heat Power, Laboratory 3532	1	0	3
	Modern Economic History 70b	3	3	0
	Total	17		
TERM 9	Composition of Technical Reports 4021	3	3	0
	Power Laboratory 4326	2	1	3
	Electrical Design Economics 4331	3	2	3
	Motor Control 4341	2	2	0
	Project 4391	2		
	Electives (See page 51)	6		
	Total	18		
TERM 10	Non-Resident Lectures 4041	1	1	0
	Application of Motors 4342	3	2	3
	Project 4392	4		
	Structures 2731	2	1	3
	Electives (See page 51)	9		
	Total	19		

Grand total for 10 terms ..... 180 hours
(not including Military Science and Tactics and Physical Training)

POWER GENERATION AND DISTRIBUTION OPTION

		CREDIT HOURS	LEC. REC. HOURS	LAB. COMP. HOURS
TERM 8	Advanced Circuit Analysis 4311	3	2	3
	Machine Theory 4321	2	2	0
	Power Systems 4361	3	2	3
	Modern Physics, Physics 44	3	3	0
	Heat Power, Lecture 3531	2	2	0
	Heat Power, Laboratory 3532	1	0	3
	Modern Economic History 70b	3	3	0
	Total	17		
TERM 9	Composition of Technical Reports 4021	3	3	0
	Power Laboratory 4326	2	1	3
	Motor Control 4341	2	2	0
	Transmission of Electric Energy 4362	3	2	3
	Project 4391	2		
	Electives (See page 51)	6		
	Total	18		

		CREDIT HOURS	LEC. REC. HOURS	LAB. COMP. HOURS
TERM 10	Non-Resident Lectures 4041	1	1	0
	High Voltage Phenomena 4371	3	2	3
	Project 4392	4		
	Structures 2731	2	1	3
	Electives (See page 51)	9		
	Total	19		

Grand total for 10 terms ..... 180 hours
(not including Military Science and Tactics and Physical Training)

INDUSTRIAL ELECTRONICS OPTION

TERM 8	Advanced Circuit Analysis 4311	3	2	3
	Machine Theory 4321	2	2	0
	Electronic Control Equipment 4411	3	2	3
	Modern Physics, Physics 44	3	3	0
	Heat Power, Lecture 3531	2	2	0
	Heat Power, Laboratory 3532	1	0	3
	Modern Economic History 70b	3	3	0
	Total	17		
TERM 9	Composition of Technical Reports 4021	3	3	0
	Power Laboratory 4326	2	1	3
	Motor Control 4341	2	2	0
	Electronic Power Converters 4421	3	2	3
	Project 4491	2		
	Electives (See page 51)	6		
	Total	18		
TERM 10	Non-Resident Lectures 4041	1	1	0
	Project 4492	4		
	Structures 2731	2	1	3
	Option Electives (See page 52)	3		
	Electives (See page 51)	9		
	Total	19		

Grand total for 10 terms ..... 180 hours
(not including Military Science and Tactics and Physical Training)

RADIO AND COMMUNICATION OPTION

		CREDIT HOURS	LEC. REC. HOURS	LAB. COMP. HOURS
TERM 8	Radio and Communication Theory 4511	3	2	3
	Communication Networks 4513	3	3	0
	Radio and Communication Laboratory 4516	3	1	3
	Modern Physics, Physics 44	3	3	0
	Heat Power, Lecture 3531	2	2	0
	Heat Power, Laboratory 3532	1	0	3
	Modern Economic History 70b	3	3	0
	Total	18		
TERM 9	Composition of Technical Reports 4021	3	3	0
	Radio and Communication Theory 4512	3	2	3
	Radio and Communication Laboratory 4517	3	1	3
	Project 4591	3		
	Electives (See page 51)	6		
	Total	18		
TERM 10	Non-Resident Lectures 4041	1	1	0
	Project 4592	3		
	Structures 2731	2	1	3
	Option Electives (See page 52)	3		
	Electives (See page 51)	9		
	Total	18		

Grand total for 10 terms.....180 hours
(not including Military Science and Tactics and Physical Training)

ILLUMINATION OPTION

		CREDIT HOURS	LEC. REC. HOURS	LAB. COMP. HOURS
TERM 8	Advanced Circuit Analysis 4311	3	2	3
	Machine Theory 4321	2	2	0
	Introductory Illumination 4611	4	2	6
	Modern Physics, Physics 44	3	3	0
	Heat Power, Lecture 3531	2	2	0
	Heat Power, Laboratory 3532	1	0	3
	Modern Economic History 70b	3	3	0
	Total	18		
TERM 9	Composition of Technical Reports 4021	3	3	0
	Power Laboratory 4326	2	1	3
	Motor Control 4341	2	2	0
	Illuminating Engineering 4612	3	2	3
	Project 4691	2		
	Electives (See page 51)	6		
	Total	18		

		CREDIT HOURS	LEC. REC. HOURS	LAB. COMP. HOURS
TERM 10	Non-Resident Lectures 4041	1	1	0
	Illumination Seminar 4615	2	2	0
	Project 4692	4		
	Structures 2731	2	1	3
	Electives (See page 51)	9		
	Total	18		

Grand total for 10 terms ..... 180 hours
(not including Military Science and Tactics and Physical Training)

PHYSICS OPTION

TERM 8	Advanced Physics Laboratory, Physics 105	3	1	6
	Heat Power, Lecture 3531	2	2	0
	Heat Power, Laboratory 3532	1	0	3
	Option Electives (See page 52)	3		
	Electives (See page 51)	9		
	Total	18		
TERM 9	Atomic Theory of Properties of Matter Physics 173	3	3	0
	Option Elective (See page 52)	6		
	Modern Economic History 70a	3	3	0
	Composition of Technical Reports 4021	3	3	0
	Electives (See page 51)	3		
	Total	18		
TERM 10	Electronic Theory of Properties of Matter; Physics of Solids and Liquids Physics 174	5	3	6
	Option Elective (See page 52)	4		
	Structures 2731	2	1	3
	Modern Economic History 70b	3	3	0
	Non-Resident Lectures 4041	1	1	0
	Electives (See page 51)	3		
	Total	18		

Grand total for 10 terms ..... 180 hours
(not including Military Science and Tactics and Physical Training)

ELECTIVE COURSES

For Advanced Military Science not more than 6 credit hours will be accredited toward meeting the requirements for the Baccalaureate Degree. This 6 hours credit is to be applied only to the Free Elective Requirements of the curriculum.

The following list of subjects defines an extensive area from which

nine of the elective hours of the ninth and tenth terms of the 5-year curriculum are to be selected. (See the Announcements of the other divisions of the University for descriptions of the courses offered.)

Elective hours without special designation and in excess of these nine may be chosen from this list, from any of the Option Electives for which prerequisites are satisfied, or any other courses in the University available to the student.

LIST OF SUBJECTS

Archaeology
Architecture
Astronomy
Biology
Botany
Dramatics
Economics
English
Fine Arts
Floriculture
Geology
Government
History
Language
Landscape Architecture
Meteorology
Music
Ornithology
Philosophy
Psychology
Sociology
Speech
Zoology

OPTION ELECTIVES

Some of the curricula provide, in the later "Option" terms, hours for "Option Electives." These are elective hours restricted to courses given within the field of the chosen Option. Except for the Physics Option, these Option Electives are listed on pages 106–119. In the Physics Option, 9 of the 13 total hours of Option Electives must be chosen from the upperclass courses in Electrical Engineering, preferably distributed as 3 hours in each of terms 8, 9, and 10. The other 4 of the 13 total hours may also be chosen from Electrical Engineering or may be any upperclass courses in Physics or Mathematics.

WAR SERVICE EXPERIENCE AND COURSES

Provision is made for veterans to obtain toward the Baccalaureate Degree some credit for war service experience or courses. The student should consult with his Class Adviser.

OPTIONS IN SCIENCE

A student who has completed the first three terms of the four-year course with a satisfactory record and with excellent grades in Mathematics, Physics, and Mechanics may, if his class adviser approves, substitute a group of courses in Physics (or in another science, such as Mathematics, Chemistry) for certain courses normally required, namely:

Accounting 3256
Kinematics 3327
Machine Design 3337
Structures 2731

Permission to continue in any of these science options may be withdrawn at any time if the student's work is not satisfactory.

A student of the School of Electrical Engineering may elect courses of instruction offered by the School of Electrical Engineering or by other schools or departments of the University, provided he has a sufficient number of elective hours available, has the necessary prerequisites, and secures the approval of his class adviser.

FOUR-YEAR CURRICULUM

Those students eligible to pursue the four-year curriculum as outlined on page (45) may on entering the seventh term of study select one of the following options:

1. Electric Power Generation and Utilization.
2. Electric Communication.
3. Administrative, Power.
4. Administrative, Communication.

FOUR-YEAR CURRICULUM (B.S. IN E.E.)

		CREDIT HOURS	LEC. REC. HOURS	LAB. COMP. HOURS
TERM 1	Analytic Geometry and Calculus, Math 60a	3	3	0
	General Physics, Physics 15	3	3	3
	General Chemistry, Chemistry 102a or Chemistry 104a	3	2	3
	Descriptive Geometry 3111	3	1	6
	Metal Working 6111	1	0	3
	Pattern Making 3401	1	0	3
	Surveying 2131	1	0	3
	English 2a	3	3	0
	Total	18		
TERM 2	Analytic Geometry and Calculus, Math 60b	3	3	0
	General Physics, Physics 16	3	3	3
	General Chemistry, Chemistry 102 or Chemistry 104b	3	2	3
	Mechanical Drafting 3112	3	1	6
	Casting Processes 6112	1	0	3
	Fundamentals of Machine Tools 3403	1	0	3
	English 2b	3	3	6
	Total	17		

In addition to taking the above courses, freshmen are required to take Military Science and Tactics and Physical Training.

		CREDIT HOURS	LEC. REC. HOURS	LAB. COMP. HOURS
TERM 3	Analytic Geometry and Calculus, Math 60c	3	3	0
	General Physics, Physics 17	3	3	3
	Mechanics 1111	5	5	0
	Engineering Materials 1221	3	3	0
	Production Machine Tools 3404	2	0	6
	Economics 3	3	3	0
	Total	19		
TERM 4	Engineering Mathematics 4031	3	3	0
	General Physics, Physics 18	3	3	3
	Basic Electrical Engineering 4111	4	3	3
	Strength of Materials 1112	3	3	0
	Accounting 3256	3	2	3
	Kinematics 3327	2	2	0
	Total	18		

In addition to taking the above courses sophomores are required to take Military Science and Tactics and Physical Training.

TERM 5	Alternating Current Circuits 4112	4	3	3
	Direct Current Machinery 4211	3	2	3
	Electric Circuit Laboratory 4116	3	1	3
	Differential Equations, Math 200	3	3	0
	Thermodynamics 3530	3	3	0
	Materials Laboratory 1231	3	1	3
	Total	19		
TERM 6	Electron Tubes and Circuits 4121	3	3	0
	Electronics Laboratory 4126	2	0	6
	Alternating Current Machinery 4221	3	2	3
	Electrical Machinery Laboratory 4216	4	2	3
	Machine Design 3337	3	3	0
	Fluid Mechanics 2331	3	3	0
	Total	18		

POWER OPTION

TERM 7	Basic Communication Systems 4131	2	1	3
	Electrical Machinery Laboratory 4226	4	2	3
	Advanced Circuit Analysis 4311	3	2	3
	Machine Theory 4321	2	2	0
	Power Systems 4361	3	2	3
	Heat Power, Lecture* 3531	2	2	0
	Heat Power, Laboratory* 3532	1	0	3
	*Electives	2		
	Total	19		

*Heat Power may be deferred to the 8th term to allow for the inclusion of an elective.

		CREDIT HOURS	LEC. REC. HOURS	LAB. COMP. HOURS
TERM 8	Non-Resident Lectures 4041	1	1	0
	Power Laboratory 4326	2	1	3
	Transmission of Electrical Energy 4362	3	2	3
	Structures 2731	2	1	3
	Option Elective (See page 52)	3		
	*Electives	7		
	Total	18		
	Grand total for 8 terms			146 hours

COMMUNICATION OPTION

TERM 7	Electronic Circuit Elements 4122	4	2	6
	Electronic Equipment Shop 4128	1	0	3
	Basic Communication Systems 4131	2	1	3
	Electrical Machinery Laboratory 4226	4	2	3
	Communication Networks 4513	3	3	0
	Heat Power, Lecture* 3531	2	2	0
	Heat Power, Laboratory* 3532	1	0	3
	*Electives	2		
	Total	19		

*Heat Power may be deferred to the 8th term to allow for the inclusion of an elective.

TERM 8	Non-Resident Lectures 4041	1	1	0
	Radio and Communication Theory 4511	3	2	3
	Radio and Communication Theory 4512	3	2	3
	Radio and Communication Laboratory 4516	3	1	3
	Structures 2731	2	1	3
	*Electives (See page 51)	6		
	Total	18		
	Grand total for 8 terms			146 hours

*These Electives may be chosen, with the approval of the Class Adviser, from any courses in the University which are available to the student.

ADMINISTRATIVE POWER OPTION

TERM 7	Basic Communication Systems 4131	2	1	3
	Electrical Machinery Laboratory 4226	4	2	3
	Power Systems 4361	3	2	3
	Heat Power, Lecture 3531	2	2	0
	Heat Power, Laboratory 3532	1	0	3
	Electives (Administrative)	7		
	Total	19		

		CREDIT HOURS	LEC. REC. HOURS	LAB. COMP. HOURS
TERM 8	Non-Resident Lectures 4041	1	1	0
	Transmission of Electrical Energy 4362	3	2	3
	Structures 2731	2	1	3
	Electives (Administrative)	12		
	Total	18		
	Grand total for 8 terms			146 hours

ADMINISTRATIVE COMMUNICATION OPTION

TERM 7	Electronic Circuit Elements 4122	4	2	6
	Electronic Equipment Shop 4128	1	0	3
	Basic Communication Systems 4131	2	1	3
	Electrical Machinery Laboratory 4226	4	2	3
	Structures 2731	2	1	3
	Electives (Administrative)	6		
	Total	19		
TERM 8	Non-Resident Lectures 4041	1	1	0
	Radio and Communication Theory 4511	3	2	3
	Radio and Communication Theory 4512	3	2	3
	Radio and Communication Laboratory 4516	3	1	3
	Option Electives (Administrative)	8		
	Total	18		
	Grand total for 8 terms			146 hours

SCHOOL OF CHEMICAL ENGINEERING

EQUIPMENT

The specialized training in Chemical Engineering is given in Olin Hall of Chemical Engineering. The courses in chemistry are given in Baker Laboratory of Chemistry. Laboratories for metallography, chemical microscopy, and other special fields of chemical engineering and chemistry provide unusual facilities for instruction and research in these special fields.

Olin Hall of Chemical Engineering was provided through the generosity of Franklin W. Olin as a memorial to his son Franklin W. Olin, Jr. This modern and well-equipped building, with about 105,000 square feet of available floor space, provides lecture-room, recitation-room, and laboratory facilities for all of the instruction in chemical engineering. The unit operations laboratory, which is about one hundred feet long and fifty feet wide, extends through three floors, and houses semi-plant scale equipment for both instruction and research. It is served by a traveling crane, and by its own shops and analytical laboratory. A considerable part of the building is subdivided into unit laboratories for advanced and graduate students.

OUTLINE OF THE INSTRUCTION

The purpose of the instruction in this School is to provide a broad foundation of training in the fundamental subjects of mathematics, chemistry, and physics, and in the essential principles and methods of engineering, and professional training in the specific field of chemical engineering. In the required curriculum a certain amount of work in cultural subjects is included. By providing elective work in the later years, the curriculum makes it possible for the student to take additional courses either in subjects outside the field of his major interest or in special and advanced technical subjects within that field.

The first four terms provide thorough training in chemistry, mathematics, and physics, and the other basic subjects on which the specific professional training is based. The later terms include more strictly technical and more advanced courses in engineering and in chemistry, and the fundamental courses in the specific field of chemical engineering. The last two terms include the more advanced work in engineering and in the specialized field. (For an outline of the course of study see page 58.)

SCHOLASTIC REQUIREMENTS

A student in the School of Chemical Engineering who does not receive a passing grade in every course for which he is registered, or who fails in any term or summer session to maintain an average grade of 75 per cent may be dropped or placed on probation.

If in the opinion of the Faculty of the School concerned, a student's general record is unsatisfactory, the student may be refused permission to continue his course even though he has met the minimum requirements in respect to the number of hours of work passed and the grades in those hours. Students who fall behind in their work may be warned, put on probation, or dropped, either from an individual course, or from the University at any time during the term.

EMPLOYMENT AFTER GRADUATION

Graduates in Chemical Engineering find employment in the design, development, operation, and administration of chemical engineering plants. There is also some demand for men with chemical engineering training for technical sales work in the chemical industries, and for editorial work on technical publications. Some graduates in chemical engineering continue their specialized training as graduate students in chemistry or chemical engineering to prepare for positions as research chemists or research engineers.

FIVE-YEAR CURRICULUM (B.Chem.E.)

		CREDIT HOURS	CONTACT HRS. LEC. & REC.	CONTACT HRS. LAB. & COMP.
TERM 1	Introductory Inorganic Chemistry, Chemistry 110A	3	3	0
	Inorganic Chemistry Laboratory, Chemistry 115	3	1	5
	General Physics 15	3	3	2½
	Analytic Geometry and Calculus, Math 60A	3	3	0
	English Literature and Composition, English 2a	3	3	0
	Drawing and Descriptive Geometry, Engineering 3114	2	1	2½
		17		
TERM 2	Introductory Inorganic Chemistry, Chemistry 110B	2	2	0
	Qualitative Analysis, Chemistry 203	5	2	7½
	General Physics 16	3	3	3
	Analytic Geometry and Calculus, Math 60B	3	3	0
	English Literature and Composition, English 2b	3	3	0
	Drawing and Descriptive Geometry, Engineering 3115	2	1	2½
		18		

In addition to taking the above courses, all freshmen must satisfy the University's requirements in Physical Training and Military Science and Tactics.

		CREDIT HOURS	CONTACT HRS. LEC. & REC.	LAB. & COMP.
TERM 3	Analytic Geometry and Calculus, Math 60c	3	3	0
	Introductory Organic Chemistry, Chemistry 305a	3	3	0
	Organic Chemistry Laboratory, Chemistry 310a	3	0	7
	Introductory Quantitative Analysis, Chemistry 220	3	3	0
	Quantitative Analysis Laboratory, Chemistry 221	3	0	7
	General Physics 17	3	2	3
		18		
TERM 4	Differential Equations, Math 60d	3	3	0
	Introductory Inorganic Chemistry, Chemistry 305b	3	3	0
	Organic Chemistry Laboratory, Chemistry 310b	3	0	7
	Chem. Eng. Stoichiometry, Engineering 5501	2	2	0
	Mechanics, Engineering 1125	3	3	0
	General Physics 18	3	2	3
	Public Speaking I	3	3	0
	or			
	Psychology for Engineering Students, Psychology 40	(3)	(3)	(0)
		20		

In addition to taking the above courses, all sophomores must satisfy the University's requirements in Physical Training and Military Science and Tactics.

TERM 5	Introductory Physical Chemistry, Chemistry 405a	3	3	0
	Physical Chemistry Laboratory, Chemistry 410a	3	1	5
	Mechanics, Engineering 1126	3	3	0
	Chem. Eng. Technology, Engineering 5203	2	2	0
	Materials of Construction, Engineering 1255	3	3	0
	Chemical Microscopy, Engineering 5851	3	1	5
	or			
	Special Methods of Chemical Analysis, Chemistry 270	(3)	(1)	(5)
	Science and Civilization, History 70a	3	3	0
	or			
	Electives	(3)	–	–
		20		
TERM 6	Introductory Physical Chemistry, Chemistry 405b	3	3	0
	Physical Chemistry Laboratory, Chemistry 410b	3	1	5
	Strength of Materials, Engineering 1127	3	3	0
	Chem. Eng. Technology, Engineering 5204	2	2	0
	Materials of Construction, Engineering 1256	3	3	0
	Special Methods of Chemical Analysis, Chemistry 270	3	$	5
	or			
	Chemical Microscopy, Engineering 5851	(3)	(1)	(5)
	Science and Civilization, History 70b	3	3	0
	or			
	Electives	(3)	–	–
		20		

		CREDIT HOURS	CONTACT HRS. LEC. & REC.	LAB. & COMP.
TERM 7	Unit Operations of Chemical Engineering, Engineering 5303	3	3	0
	Unit Operations Laboratory, Engineering 5353	3	2	3
	Heat Power, Engineering 3535	3	3	0
	Materials Testing Laboratory, Engineering 1231	3	1	3
	Chemical Engineering Thermodynamics, Engineering 5103	3	3	0
	Electives	3	–	–
	or			
	(Science and Civilization, History 70a)	–	–	–
		18		
TERM 8	Unit Operations of Chemical Engineering, Engineering 5304	3	3	0
	Unit Operations Laboratory, Engineering 5354	3	2	3
	Heat Power, Engineering 3536	3	3	0
	Chemical Engineering Thermodynamics, Engineering 5104	2	2	0
	Library Use, Engineering 5711	1	1	0
	Plant Inspections, Engineering 5701	1	–	–
	Electives	3	–	–
	Science and Civilization, History 70 or (Elective)	3	3	–
		19		
TERM 9	Electrical Engineering 4951	4	3	3
	Chemical Equipment Design, Engineering 5603	2	2	0
	Chemical Plant Design, Engineering 5605	2	1	3
	Chemical Engineering Computations, Engineering 5503	2	2	0
	Senior Project, Engineering 5953	3	0	9
	Chemical Engineering Economics, Engineering 3253 or (Elective)	3	2	3
	Electives	4	–	–
		20		
TERM 10	Electrical Engineering 4952	4	3	3
	Chemical Engineering Computations, Engineering 5504	2	2	0
	Chemical Equipment Design, Engineering 5604	2	2	0
	Chemical Plant Design, Engineering 5606	2	1	3
	Senior Project, Engineering 5954	3	0	9
	Electives	3	–	–
	or			
	Chemical Engineering Economics, Engineering 3253	(3)	(2)	(3)
	Electives	4	–	–
		20		

Elective courses may be taken in any college of the University. The selection must be approved by the student's adviser.

OPTIONS IN CHEMICAL ENGINEERING

A student in Chemical Engineering may select his elective courses in any one of several optional fields to provide somewhat more extensive training than is afforded by the required courses in the curriculum. The student may also, if he so desires, arrange his elective work to provide a cultural background broader than that given by the required courses. The selection of electives must be approved by the class adviser.

THE GRADUATE SCHOOL OF AERONAUTICAL ENGINEERING

The establishment of a Graduate School of Aeronautical Engineering at Cornell University, Ithaca, New York, was authorized by the Board of Trustees in October, 1945. Actual operation of the new school began in September, 1946.

The primary objective of the School is the training of selected engineering and science graduates in the more scientific aspects of aeronautics. This training is intended especially to prepare the students to carry out research and development engineering of high quality in the aeronautical and related industries, and in aeronautical scientific institutions.

To this end, students are admitted to this School who have demonstrated, in their undergraduate careers, more-than-average abilities in analytical subjects, and who have shown adequate promise of carrying on graduate study successfully.

In the Aeronautical Engineering program, considerable emphasis is placed upon original research, both theoretical and experimental. Throughout the academic year, close contact is maintained between the Graduate School at the University and the Cornell Aeronautical Laboratory in Buffalo, New York. In addition, it is expected that certain periods of employment at the Laboratory will be offered to Aeronautical Engineering students—usually during their summer vacations. Students will be urged to take advantage of such employment, if it is available. It is also possible that certain experimental equipment of the Laboratory will occasionally be available to graduate students in connection with their original research.

The Graduate School of Aeronautical Engineering will be equipped with a fluid-mechanics laboratory, on or near the campus in Ithaca, for fundamental scientific research in fluid mechanics and aerodynamics.

ADMISSION

Application for admission to the Graduate School of Aeronautical Engineering as a candidate for the degree M.Aero.E. should be made directly to the Director of the Graduate School of Aeronautical Engineering, College of Engineering, Cornell University. A special application blank for this purpose can be obtained from the office of the

Director. It should be sent directly to the Director of the Graduate School of Aeronautical Engineering.

Students who desire to work for the degree Ph.D. with Aeronautical Engineering as their Major Subject must be admitted to the Graduate School of the University in the usual manner. They should make application to the Dean of the Graduate School, using the application blank for admission to the Graduate School.

The degree M.Aero.E. is awarded under the jurisdiction of the College of Engineering, and candidates for this degree are not necessarily admitted to the Graduate School of the University. The degree is awarded upon satisfactory completion of a required curriculum of studies and an acceptable thesis. Candidates for this degree do not have Special Committees and do not select a Minor Subject.

CURRICULUM

The Aeronautical Engineering Curriculum is being planned to accomplish the broad objectives stated above. Courses of study are provided leading to the degree Master of Aeronautical Engineering and to the degree Doctor of Philosophy with Aeronautical Engineering as the Major Subject.

A. Course of Study Leading to the Degree M.Aero.E.

It is anticipated that two years' study will ordinarily be required for the degree M.Aero.E. It should be noted, however, that only one year's residence is required, so that students entering the School with credit for a sufficient number of the required courses may be able to qualify for the degree in one year.

In the recommended program outlined below, the courses required for the M.Aero.E. degree have been supplemented by additional Aeronautical Engineering courses and electives, so as to result in a balanced program of approximately 15 credit-hours a term. Required courses are indicated by an asterisk (*).

It should also be noted that the schedule is planned so that, at the end of the first year of graduate study, the student has completed a balanced aeronautical curriculum, which should qualify him for an engineering position in the aeronautical or related industries. It is anticipated that, should such a student find it impossible to complete the second year of graduate study—for financial or other reasons—he could nevertheless be recommended for such an industrial position.

FIRST YEAR OF GRADUATE STUDY

		CREDIT HOURS		
FIRST TERM				
7601	*Mathematics in Aeronautics I	3	3	0
7101	*Airplane Mechanics I	3	3	0
7201	*Gasdynamics I	3	3	0
7401	*Airplane Design I	2	2	0
7403	*Airplane Design III	1	1	0
7501	Experimental Methods in Aeronautics I	2	1	2½
7901	Seminar in Aeronautical Engineering	1	1	0
		15		
SECOND TERM				
7602	*Mathematics in Aeronautics II	3	3	0
7102	Airplane Mechanics II	3	3	0
or	* or			
7203	Aerodynamics of Power Plants	3	3	0
7202	*Gasdynamics II	3	3	0
7402	*Airplane Design II	2	2	0
7404	*Airplane Design IV	1	1	0
7502	Experimental Methods in Aeronautics II	2	1	2½
7901	Seminar in Aeronautical Engineering	1	1	0
		15		

*Required for the degree M.Aero.E.

SECOND YEAR OF GRADUATE STUDY

		CREDIT HOURS		
THIRD TERM				
1163	Applied Elasticity	3	3	0
	* or			
1162	Mechanics of Vibration			
7301	*Theoretical Aerodynamics I	3	3	0
7203	Aerodynamics of Power Plants	3	3	0
	or			
	Approved Elective			
7303	*Theoretical Aerodynamics III	3	3	0
7901	Seminar in Aeronautical Engineering	1	1	0
7801	*Research in Aeronautical Engineering	3†		
		16		

*Required for the degree M.Aero.E.

†A total of six (6) credit hours in Research in Aero. E. will be required for the degree M.Aero.E.

		CREDIT HOURS		
FOURTH TERM				
1164	Applied Elasticity	3	3	0
* or				
1165	Theory of Elastic Stability			
7302	*Theoretical Aerodynamics II	4	4	0
7304	Theoretical Aerodynamics IV..			
or	or			
7405	Aero-Elastic Problems	3	3	0
7901	Seminar in Aeronautical Engineering	1	1	0
7801	*Research in Aeronautical Engineering	5†		
		16		

*Required for the degree M.Aero.E.

†A total of six (6) credit hours in Research in Aero. E. will be required for the degree M.Aero.E.

B. Courses Leading to the Degree Ph.D.

Students will be admitted to candidacy for the degree Ph.D. as set forth in the current Announcement of the Graduate School. General requirements such as Residence, Major and Minor Subjects, Requirements in Foreign Languages, Qualifying Examinations, and Thesis are also explained there. Each candidate is required to complete a schedule of courses acceptable to his Special Committee, as explained in the Announcement.

PREPARATION FOR GRADUATE STUDY

The Graduate School of Aeronautical Engineering will admit students holding a baccalaureate degree in any branch of engineering, physics, or mathematics, providing that their undergraduate scholastic records are such as to indicate ability to handle graduate study. The course of study in Engineering Physics is especially recommended to students who expect to enter this School after graduation.

It will be possible for Cornell students in the five-year undergraduate programs to complete the requirements for the degree M.Aero.E. in one year of graduate study instead of the normal two years, if they complete a sufficient number of the required graduate courses as electives in their undergraduate programs. The following courses are recommended for this purpose:

7101, 7102	Airplane Mechanics I and II
7601, 7602	Mathematics in Aeronautics
or	or
Phys. 405	Mathematical Methods in Physics (two terms)
7201, 7202	Gasdynamics I and II

7401, 7402	Airplane Design I and II
7403, 7404	Airplane Design III and IV
7501, 7502	Experimental Methods in Aeronautics I and II
1163, 1164	Applied Elasticity

To be admitted to any of the graduate courses listed above, an undergraduate student must

(1) be a regularly enrolled student in at least the seventh term of one of the engineering, physics, or mathematics curricula at Cornell University,

(2) show promise, by his previous scholastic record or otherwise, of ability satisfactorily to pursue advanced study and research, and

(3) have his admission to the courses recommended by the Director of the Graduate School of Aeronautical Engineering (or the Chairman of the department concerned) and approved by the Dean of the College of Engineering

It is recommended that all students who expect to enter the Graduate School of Aeronautical Engineering include in their programs the following courses, or their equivalents:

Ma 200	Differential Equations
1111	Engineering Mechanics
1112, 1113	Strength of Materials
1161	Advanced Engineering Mathematics

DEPARTMENT OF ENGINEERING PHYSICS

OBJECTIVE

The Department of Engineering Physics is a new department constituted so as to provide a type of education and training which will effectively bridge the gap between that of the basic sciences and engineering. The general aim is to prepare students for a prospective career in technical research and advanced engineering development. As a result of the expanding technological activities in the country, the industrial research laboratories and engineering development laboratories are in urgent need of graduates with the vigorous and exacting course of study which the curriculum of this department provides.

FACULTY

The administrative arrangement of the department is such that the Faculty of the Department includes leading members of the Department of Physics in the College of Arts and Sciences, and the several Schools of Engineering in the College of Engineering.

CURRICULUM

The curriculum leading to the degree of Bachelor of Engineering Physics covers intensive study over a five-year period. The course of study is designed to combine the broad, basic scientific and analytical training of the physicist with the knowledge of the properties of materials and the technological principles of the engineer. The subject matter falls into three main categories: fundamental science, namely, mathematics, physics, and chemistry; the properties and treatment of materials; and engineering practice.

For training in research, the student terminates the course by carrying out a semi-research project in a special field of his own choice, under the direction of a faculty member who is an authority in the selected field. There are a great variety of these special fields in physics and engineering. These fields include topics in electron physics, atomic physics, optics, x-rays and crystal structure, spectroscopy, nuclear physics, engineering electronics, communications, electrical machinery, ultra high frequency generation and propagation, circuit analysis, elasticity and stress analyses, properties of materials, engineering mechanics, aerodynamics, etc.

ELECTIVES AND LIBERAL COURSES

Considerable flexibility in the technical courses is provided in the last few terms of the curriculum to allow the student to follow some technical fields somewhat more intensively as his interest in certain fields develops. To permit this, 17 hours of technical electives are provided which may be selected, with the permission of the student's adviser, from the following subjects: *Physics, Mathematics, Chemistry, Physical Metallurgy, Advanced Mechanics and Elasticity, Fluid Mechanics, Aerodynamics, Ultra-high frequency.* In addition to this, there are alternatives in mathematics, physics, and engineering provided in the course schedule. The choice in these alternatives will depend largely on the student's particular ability or interest.

The curriculum provides for approximately 30 hours of liberal courses. Of these, there are 15 hours required and 15 hours to be elected. These electives must be chosen from the following subjects: *History of Science, American History, Psychology, Economics, Public Speaking, Business Law, Corporate and Industrial Organization, Industrial and Labor Relations.* Electives in other subjects may be taken in special instances, with the permission of the Engineering Physics Faculty.

FIVE-YEAR CURRICULUM

		CREDIT HOURS	CONTACT HRS. LEC. REC.	LAB. COMP.
TERM 1	Mathematics 60a, Analytic Geometry and Calculus	3	3	0
	Physics 15, Mechanics	3	3	2½
	General Chemistry 102a or 104a	3	3	2½
	English 2a	3	3	0
	Drawing 3114	2	1	2½
	Language (elective)	3	3	0
	Fundamentals of Machine Tools 3403	1	0	2½
		18		
TERM 2	Mathematics 60b, Analytic Geometry and Calculus	3	3	0
	Physics 16, Wave motion, Sound and Heat	3	3	2½
	General Chemistry 102b or 104b	3	3	2½
	English 2b	3	3	0
	Drawing 3115	2	1	2½
	Language (elective)	3	3	0
	Metal working 6111	1	0	2½
		18		

In addition to these courses, freshmen must satisfy the University's requirements in Military Science and Tactics and Physical Training.

		CREDIT HOURS	CONTACT HRS. LEC. REC.	LAB. COMP.
TERM 3	Mathematics 60c, Analytic Geometry and Calculus	3	3	0
	Physics 17, Electricity and Magnetism	3	3	2½
	Organic Chemistry 5761	2	2	0
	Physics 65, Mechanics and Properties of Matter	3	3	0
	Statics and Strength of Materials 1121	3	3	0
	Liberal Electives	3	3	0
		17		
TERM 4	Mathematics 200, Differential Equations	3	3	0
	Physics 18, Electricity, Magnetism, and Light	3	3	2½
	Physical Chemistry 5762	2	2	0
	Statics and Strength of Materials 1122	3	3	0
	Electric and Magnetic Circuits (modified) 4111	3	3	2½
	Liberal Electives	3	3	0
		17		

In addition to these courses, sophomores must satisfy the University's requirements in Military Science and Tactics and Physical Training.

TERM 5	Physics 111, Analytical Mechanics	3	3	0
	Physics 123, Electricity and Magnetism	3	3	0
	Electric and Magnetic Circuits (modified) 4112	3	3	2½
	Electric Circuit Laboratory 4116	3	1	3
	Engineering Materials 1221	3	3	0
	Thermodynamics and Kinetic Theory 8121	3	3	0
		18		
TERM 6	Physics 124, Electricity and Magnetism	3	3	0
	Mechanics of Vibrations 1162	3	3	0
	Engineering Materials 1222	3	3	0
	Thermodynamics and Kinetic Theory 8122	3	3	0
	Electronics 4121	3	3	0
	Liberal Elective	3	3	0
		18		
TERM 7	Mathematics 271, Fourier Series and Transforms or Mathematics 215, Advanced Calculus	3	3	0
	Atomic Physics 173	3	3	0
	Engineering Materials 1231	3	1	2½
	Electrical Machinery	3		
	Electronics 4122	4	2	6
	Liberal Elective	3		
		19		

		CREDIT HOURS	CONTACT HRS. LEC. REC.	LAB. COMP.
TERM 8	Physics 174, Electronic Properties of Matter	5	3	5
	Electrical Machinery	3		
	Radio and Communication Theory 4511 or Communication Networks 4513	3	2	3
	Mathematics 215, Advanced Calculus or Technical Elective	3	3	0
	Technical Electives	5		
		19		
TERM 9	Physics 405, Mathematical Methods or Mathematics 480, Differential Equation of Math. Physics	3	3	0
	Physics 135, Optics or Research Project	5	3	5
	English Composition	3	3	0
	Physics 320, Special Topics Laboratory	2	1	2½
	Technical Electives	6		
		19		
TERM 10	Physics 405, Mathematical Methods or Mathematics 480, Differential Equations of Math. Physics	3	3	0
	Research Project or Physics 165, Wave Motion and Sound	5	3	5
	Technical Electives	6		
	Liberal Elective	3		
		17		

DESCRIPTION OF COURSES

THE COURSES listed in the preceding curricula are described in the following sections of this Announcement. Courses are described under the heading of the school or college in which the course is offered. Courses in Chemistry, English, Mathematics, Physics, and certain courses in Economics, are offered by the College of Arts and Sciences. Courses in Military Science and Tactics and Physical Training, under the direct supervision of the University as a whole, are listed in a general section.

The courses designated by four digit numbers are offered by the College of Engineering. The first digit represents the School or Department. Descriptions of courses will be found in the section of this announcement as follows:

1. General Engineering
2. Civil Engineering
3. Mechanical Engineering
4. Electrical Engineering
5. Chemical Engineering
6. Metallurgical Engineering
7. Aeronautical Engineering
8. Engineering Physics

For courses in other colleges not described here, to be taken as electives, see the Announcement of the appropriate college.

CIVIL ENGINEERING

Courses in Civil Engineering are listed under the following headings: Administrative, Astronomy, Drawing, Hydraulics, Hydraulic Engineering, Materials of Construction, Mechanics of Engineering, Municipal and Sanitary Engineering, Regional and City Planning, Structural Engineering, Surveying, and Transportation.

ADMINISTRATIVE ENGINEERING

2901. *CONSTRUCTION METHODS.* Required of all Civil Engineering students. Credit three hours. A fundamental course designed to acquaint the student with the financial and economic principles underlying human enterprises, both public and private; and with the agencies—money, men, materials, and machines—utilized in carrying out construction projects, and their correlation and control. Methods and processes of construction with special attention to the equipment available and

its adaptability to various kinds of work. Problems and reports on references to periodical literature are required of all students. Lectures and recitations three hours a week. Messrs. CRANDALL and PERRY.

2902. *ENGINEERING LAW.* Required in fourth year. Either term. Credit three hours. An introductory course in the laws of contract, tort, agency, real property, water rights, form of business organization, sales, and negotiable instruments; special emphasis on contract documents required on construction work; collateral topics such as workmen's compensation, mechanics' liens, arbitration, and patent law are also included. Lectures and recitations three hours a week. Textbook: *Contracts in Engineering,* Tucker. Messrs. THATCHER, CRANDALL, and PERRY.

2903. *ECONOMICS OF ENGINEERING.* Required in the fourth year. Either term. Credit three hours. Prerequisite, Construction Methods, Economics 3, and Accounting. The economic aspects of engineering and the application of principles of management to the work of the engineer; economic selection of materials, equipment, and structures; studies for the replacement of existing units; plant layouts; public works economy; the technique of estimating quantities and costs for various types of engineering projects. Three recitations a week. Messrs. THATCHER and CRANDALL.

2904. *PUBLIC ADMINISTRATION.* Required in fifth year. Either term. Credit three hours. A course to acquaint the prospective city engineer, superintendent of public works, city manager, or executive engineer in charge of various government bureaus or departments with the administrative problems he must face in addition to strictly technical engineering duties. Budgets, controlling legislation, civil service regulations, city planning, and public administration practices are included. Lectures and recitations three hours a week. Mr. CRANDALL.

2905. *VALUATION ENGINEERING.* Elective for fourth- and fifth-year students. Credit three hours. Prerequisites, Construction Methods, Accounting, Engineering Law or concurrently therewith. Theory and practice of valuation for purposes of utility rate making, purchase or sale, eminent domain or condemnation cases, securities, bank loans and mortgages, insurance, uniform systems of accounting, and improved management. Lectures and recitations three hours a week. Mr. CRANDALL.

2906. *ADVANCED ENGINEERING LAW.* Elective for fourth- and fifth-year students. Credit three hours. Prerequisite, Engineering Law 2902. An extension, by the use of case material, of some of the legal principles covered in Course 2902, particularly the laws applying to the various phases of construction contracts and employer-employee relationships; additional fields included are suretyship, insurance, bailments, and conditional sales. Lectures and recitations three hours a week. Textbook: *Law for Engineers and Architects,* Simpson and Dillavou. Mr. THATCHER.

2907. *CONSTRUCTION MANAGEMENT.* Elective for fourth- and fifth-year students. Credit three hours. Prerequisites, Construction Methods, Economics of Engineering, Accounting. Planning and operation of construction projects by the civil engineer, including coordinated organization of men and machines, scheduling and estimating, purchasing, selection and training of men, operation and maintenance of equipment, cost keeping and reports, pay systems, accident prevention, and other related factors. Lectures and recitations three hours a week. Mr. CRANDALL.

2941. *GENERAL CIVIL ENGINEERING.* Either term. Problems in practical design may be taken in any department, the work to be supervised by the department concerned in cooperation with the Department of Structural Engineering in regard to structural features.

2942. *ADMINISTRATIVE ENGINEERING RESEARCH.* Either term. Special problems relating to the economic, legal, and financial aspects of engineering construction projects, management of public works and appraisals. Messrs. THATCHER and CRANDALL.

2943. *ADMINISTRATIVE ENGINEERING SEMINAR.* One to six hours credit. Elective. Open to specially selected seniors or graduate students. Abstraction and discussion of technical papers and publications in the field of administrative engineering.

ASTRONOMY

182. *THE ELEMENTS OF FIELD ASTRONOMY.* Required of Civil Engineering sophomores in the four-year curricula. Credit two hours. Prerequisite, Surveying 210 (or Astronomy 180 and Mathematics 3). The determination of time, latitude, longitude, and azimuth by observations on the sun and stars using a surveyor's transit and a watch. Textbooks: *Textbook of Practical Astronomy* by Nassau and *Determination of Azimuth, Time, and Latitude by* Boothroyd. One one-hour recitation and one two-hour laboratory period a week, some of the laboratory periods being in the late afternoon and at night for observations on sun and stars. Mr. SHAW.

183. *NAVIGATION AND NAUTICAL ASTRONOMY.* Elective. Either term. Credit three hours. Prerequisite, Mathematics 3. Position of a ship or airplane by dead reckoning and by astronomical observation, with laboratory exercises, using sextant to determine time, latitude, and longitude. Students who already have two hours credit for Course 182 will get one hour additional credit upon completion of the extra work necessary to obtain credit for Course 183. Civil Engineering sophomores may take this course instead of Course 182 and count the extra hour credit as a Civil Engineering Elective. Textbooks: *The Essentials of Modern Navigation,* by Wylie and *Textbook of Practical Astronomy* by Nassau. Each student should have access to a copy of the *American Nautical Almanac* for the year. Lectures and recitations M at 10 with two two-hour laboratory periods a week to be arranged. Some of the laboratory and recitation periods during several weeks of the term are used for sextant observations of the sun during the day and of the moon, stars, and planets at night. This course should be of special interest to those who contemplate becoming aviators or navigators. Mr. SHAW.

186. *GEODETIC ASTRONOMY.* Elective. Either term. Credit three hours. Prerequisites, Astronomy 182 and Advanced Surveying 2102 (or Mathematics 4a and 4b and General Astronomy 187) or approved equivalents. The theory and practice of the precise determination of time, latitude, longitude, and azimuth. Figure of the Earth and Isostacy will also be considered. Textbook: Hosmer's *Geodesy,* Second Edition. Lecture and discussion, one hour a week and evening observing at the Observatory together with the reduction of observations will average about five hours a week throughout the term. The laboratory work may be spread throughout the year if it seems desirable to do so. Mr. SHAW.

DESCRIPTIVE GEOMETRY AND DRAWING

2001. *DRAWING.* Either term. Credit three hours. A course in the fundamentals of the graphic language as used in engineering. It is laid out to include the care and use of drafting instruments, freehand lettering, titles, geometrical problems, simple orthographic projection, freehand and technical sketching, and print reproduction. Text: "Engineering Drawing," French. Messrs. JENKINS, PERRY, SPRY, and others.

2002. *DRAWING.* Either term. Credit three hours. Prerequisite course 2001. Instruction and drill in the fundamental conception of Descriptive Geometry, dealing with graphic solution of advanced space problems, both theoretical and practical. It is designed to develop the powers of visualization and analysis by the methods of revolution and auxiliary views. Problems involving the measurement of angles and distances are given consideration, after the use of exercises on the point, line, and plane. In addition, the course includes a study of intersections and the development of surfaces, mining problems, graphic solutions of stresses, and other problems of a practical nature. Text: "Engineering Descriptive Geometry", Rowe. Messrs. JENKINS and McNEVIN.

2003. *DRAWING.* Either term. Credit three hours. A continuation of courses 2001 and 2002. The objective of this course is to develop a more complete grasp of the principles of projection covered in the earlier courses, and to give further training in visualization. Emphasis is placed on sections, scale drawings, conventional signs, and pictorial representation. Practical civil engineering problems such as topographic mapping, structural drafting, and charts and graphs are included in the course. Messrs. JENKINS, THATCHER, and others.

2004. *ADVANCED DRAWING.* Elective for upperclassmen. Either term. Credit one to three hours. Problems in concrete, structural, topographical, highway, and sanitary drafting; engineering drawings, rendered in color, to enable the student to supplement ordinary drawings with artistic representations so portrayed as to be readily intelligible to non-technical persons. Mr. JENKINS.

2051. *DRAWING.* Second term in the four-year course. Credit three hours. Orthographic projection, sections, scale drawings, practical problems, tracing, blueprinting, conventional signs, topographic mapping, isometric drawing. Textbook: *Engineering Drawing,* French. Mr. JENKINS and assistants.

2052. *DRAWING.* Required of all sophomores in the four-year course in Civil Engineering. Fourth term. Credit two hours. Projections and intersections in practical problems; structural detailing and tracing; reading engineering drawings. Textbook: *Engineering Drawing,* French. Mr. JENKINS and assistants.

THEORETICAL AND EXPERIMENTAL HYDRAULICS

2301. *ELEMENTARY FLUID MECHANICS.* Fifth term, five-year curriculum. Credit three hours. Prerequisite 1133. Statics, dynamics of fluid flow, viscosity, law of continuity, energy equation, turbulence, and resistance of submerged bodies. Simple applications of mechanics principle to the flow of fluids through orifices, pipes, open channels, and weirs. Textbook: *Elementary Fluid Mechanics,* Vennard. Three recitations a week. Messrs. SCHODER, REID, BOGEMA, and PRIEST.

2302. *HYDRAULICS.* Sixth term, five-year curriculum. Credit three hours. Prerequisite 2301. A correlation of existing hydraulic data and flow relations with the principles of fluid mechanics to provide the student with a practical means of attacking the common problems of flow of liquids. Consideration is given to such control and measuring devices as the orifice weir, venturi meter, and nozzle; flow in pipe systems; pressure waves; flow in open channels; turbines and centrifugal pumps. Textbook: *Hydraulics,* Schoder and Dawson. Two recitations and one laboratory period a week. Messrs. SCHODER, REID, BOGEMA, PRIEST, and assistants.

2303. *ADVANCED HYDRAULICS.* Elective. Credit three hours. Prerequisite 2302. This course involves more detailed and extended theory and application than the first courses. Three lectures or recitations a week. Mr. BOGEMA.

2304. *HYDRAULIC MEASUREMENTS.* Elective. Credit three hours. Prerequisite 2302. Experiments involving current meters and floats in canal or river; Pitot tubes; water meters, weirs, characteristics in detail of orifices, nozzles, Venturi meters, pipes, the determination of efficiency, capacity, and characteristics of hydraulic machinery. Two periods a week in laboratory or computing room and one lecture period. Messrs. SCHODER and REID.

2305. *HYDRODYNAMICS.* Elective. Credit three hours. Prerequisite 2302 (or 2351) and Differential Equations. Physical properties of fluids, equations of motion, circulation, irrotational motion, conformal transformation, laboratory methods for determining flow nets, pressure distribution on submerged surfaces, vorticity, equations of viscous flow, separation, drag, turbulence, dimensional analysis and similitude. Three recitations a week. Mr. PRIEST.

2306. *PUMPS AND TURBINES.* Elective. Credit three hours. Prerequisite 2302 or 2351. Theory and characteristics of the hydraulic ram, impulse wheel, reaction turbine selection and testing. Two recitations and one laboratory or computation period a week. Mr. BOGEMA.

2307. *FLOW IN OPEN CHANNELS.* Elective. Credit three hours. Prerequisite 2302. Uniform and non-uniform steady flow. Energy criteria, hydraulic jump, surges; transitions, bends; obstructions, effects of improvements; flood rating, tidal flow. Two lectures and one computing period a week. Messrs. SCHODER and REID.

2308. *HYDRAULIC MODELS.* Elective. Credit three hours. Prerequisite 2303. Theory and practical use of models in designing hydraulic structures. One recitation and two laboratory or computing periods a week. Messrs. SCHODER, REID, BOGEMA, and PRIEST.

2331. *FLUID MECHANICS.* Required for students in Mechanical and Electrical Engineering. Credit three hours. Either term. Prerequisite Mechanics 1131. Properties of fluids, gas laws, viscosity; static pressures, center of pressure on plane and curved surface; gages and manometers; buoyant force and equilibrium of floating and immersed bodies; dynamics of fluids, Bernoulli's theorem; impulse and momentum, open jets, vanes; flow in pipes, Reynolds' number, hydraulic gradient, divided flow; orifices, nozzles, weirs, and gates; open-channel flow; hydraulic similitude and dimensional analyses. Textbook: *Fluid Mechanics,* Cox and Germano. Two recitations and one laboratory period a week. Messrs. SCHODER, REID, BOGEMA, and PRIEST.

2342. *HYDRAULICS.* Either term. Prerequisite, course 2351 or its equivalent. The subject and scope of the investigations in experimental or theoretical hydraulics should be selected by conference at the beginning of the term if not previously arranged. It is often desirable and is permissible for two students to work together on the same investigation. Written reports are required but the text need not be typewritten in thesis style. These reports are kept by the department. In most cases it is necessary to arrange a definite schedule for work in the laboratory to avoid conflicts. Messrs. SCHODER, REID, BOGEMA, and PRIEST.

2343. *HYDRAULICS SEMINAR.* One to six hours credit. Elective. Open to specially selected seniors or graduate students. Abstraction and discussion, of technical papers and publications in the hydraulic field.

2351. *HYDRAULICS.* Required of all Civil Engineering juniors in the four-year programs. Either term. Credit four hours. Prerequisites, courses 1136 and 1138. Hydrostatic pressure; manometers; strength of pipes; stability of dams; immersion and flotation; flow of liquids through orifices, nozzles, Venturi meters, and pipes,

and over weirs; time required to empty tanks and reservoirs; simple, compound, branching, and looping pipes; elementary power calculations in common pumping and fire protection problems; flow of water in open channels; pressure on stationary solids due to deviated flow. Elementary consideration of modern water wheels. Textbook: Schoder and Dawson's *Hydraulics*. Three recitations and one laboratory period a week. About ten of the recitation periods are utilized for demonstration lectures. Messrs. SCHODER and BOGEMA.

HYDRAULIC ENGINEERING

2401. *APPLIED HYDROLOGY*. Either term. Credit two hours. Prerequisite, course 2351. The term is devoted to the methods of making the preliminary investigations for a hydraulic development involving the use of a stream; general hydrology; water resources of a basin; methods of systematic stream gaging; stream characteristics; working up data; use of mass curves in storage studies; percolating waters; probably dependable draft, etc.; a study of the working conditions and fundamental data for designing conduits, distributing reservoirs. In the problems, applications of the text are made to particular localities, the topographic maps of drainage basins forming the bases of the problems. Students contemplating extensive election of courses in the hydraulics group should arrange to take this course the first term. Courses 2403, 2404, and 2405 are elaborations of details in this course. Textbooks: Turneaure & Russell, *Public Water Supplies;* Hoyt & Grover, *River Discharge*. Two recitations a week. Mr. DONLEY.

2402. *HYDRAULIC ENGINEERING*. Required in the five-year curriculum. Credit three hours. Prerequisite, 2401. An introductory course in Hydraulic Engineering. Three recitations a week. Mr. DONLEY.

2403. *HYDRAULIC CONSTRUCTION*. Elective for seniors and graduates. Second term. Credit three hours. This is a computing and designing course dealing with problems of water storage and the design and construction of dams by means of lengthy problems to be solved by graphical and analytical methods, and involving the economics of water storage at a given site; the design of a high masonry dam by Wegmann's Method and the tests for safety and stability of design, and the analysis of stresses and stability. Three design periods a week. Text: *Design of Dams*. Justin, Creager, and Hinds. Mr. DONLEY.

2404. *WATER POWER*. Elective. Seniors and graduates. Either term. Credit three hours. Prerequisites, courses 2401 and 2351, or the equivalent. The subject matter of the course covers the technique of hydraulic turbines, the analysis of test data, a study of the adaptation of turbine types to working conditions, unsteady flow and surging in long conduits, governing, and the analysis of the power available at a low head millsite. Textbook: Mead's *Water Power Engineering*. Three lectures and recitations a week and the working of three lengthy problems during the term. Mr. DONLEY.

2405. *HYDRAULIC ENGINEERING*. Elective. Seniors and graduates. First term. Credit three hours. The theory of percolating water; ground water development; recent developments in soil technology and the design and construction of earthen dams and levees; theory of design of gravity and arch masonry dams and distribution of stresses in such structures; spillway design; preparation of dam sites; construction methods and plants. Lectures, recitations, and abstracting of references. Mr. DONLEY.

2406. *CONSERVANCY AND RECLAMATION PROBLEMS*. Elective. Seniors and graduates. Any term. Credit three hours. Flood flow estimates; planning for and

designing of flood protection structures, irrigation, and drainage works. Lectures, recitations, and abstracting of references. Mr. DONLEY.

2407. *WATER POWER AND PUMPING PLANTS.* Elective. Seniors and graduates. Second term. Credit three hours. This is a computing and designing course devoted to the problems of designing and detailing power and pumping plants. Prerequisites, courses 2401 and 2404. Mr. DONLEY.

2408. *HARBOR ENGINEERING.* Elective. Credit three hours. Study of wave action; currents, tides; shore protection, wharves, bulkhead, jetty design and construction; channel and revetment work; dredging and reclamation of land; cargo handling; transportation in dock areas; storage and warehouse facilities. Three recitations a week. Mr. DONLEY.

2441. *HYDRAULIC ENGINEERING DESIGN.* Any term. Prerequisite course 2351. For best results Hydraulic Engineering Design should be preceded by Course 2401 but the two may be taken concurrently. The purpose of the course is to go more into detail in selected phases of hydraulic engineering and is not to duplicate in large part work regularly given in the scheduled courses in hydraulic and structural engineering. Mr. DONLEY.

2443. *HYDRAULIC ENGINEERING SEMINAR.* One to six hours credit. Elective. Open to specially selected seniors or graduate students. Abstraction and discussion of technical papers and publications in the hydraulic engineering field. Mr. DONLEY.

MATERIALS OF CONSTRUCTION

1211. *MATERIALS OF CONSTRUCTION.* Required of all third-year students in the five-year curriculum. Prerequisite courses, Mechanics 1133. Credit three hours. The materials studied are lime, cement, stone, brick, sand, timber, ores, cast iron, wrought iron, steel, and some of the minor metals and alloys. The chemical and physical properties, uses, methods of manufacture, methods of testing, and unit stresses of each material are considered, particular emphasis being laid on the points of importance to engineers. Three recitations a week. Mr. SCOFIELD.

1212. *MATERIALS OF CONSTRUCTION.* Required of all third-year students in Civil Engineering in the five-year curriculum. Second term. Prerequisite courses, Mechanics 1134, and Materials 1211. Credit three hours. Experimental determination of the properties of materials by mechanical tests. Study of testing machines (their theory, construction, and manipulation); calibration of testing machines and apparatus; commercial tests of iron and steel; tensile, compressive, torsional, shearing and flexure tests of metal and various woods with stress-strain observations; tests of concrete, concrete aggregate, plain concrete. One recitation and two laboratory periods a week. Mr. SCOFIELD.

1213. *MATERIALS OF CONSTRUCTION.* Required of all fourth-year students in Civil Engineering in the five-year curriculum. Either term. Credit three hours. Prerequisite courses, Mechanics 1134; Materials 1212; and must be taken with, or preceeded by Structural Engineering Course 2715. More advanced tests of structural materials, with especial reference to stress and stress distribution in columns, beams, and slabs. Study of the effect of heat-treatment and welding is included. Two 2½-hour laboratory periods a week. Mr. SCOFIELD.

1214. *ENGINEERING MATERIALS RESEARCH.* Either term. Credit one hour for forty hours of actual work. A project may be started during the junior year for completion in the senior year. Prerequisites, courses 1225 and 1226 or their equivalents. Special investigations of an advanced nature of the properties of structural

units and the materials of construction. The aim of the course is to secure results by proper investigational methods which are of the caliber and scope deemed essential for publication. Mr. SCOFIELD.

1215. *MATERIALS SEMINAR.* One to six hours credit. Elective. Open to specially selected seniors or graduate students. Abstraction and discussion of technical papers and publications in the materials field. One one-hour period a credit hour.

1225. *MATERIALS OF CONSTRUCTION.* Required of all Civil Engineering juniors in the four-year curricula. Either term. Credit three hours. Prerequisite course 1138. The materials studied are lime, cement, stone, brick, sand, timber, ores, cast iron, wrought iron, steel, and some of the minor metals and alloys. The chemical and physical properties, uses, methods of manufacture, methods of testing, and unit stresses of each material are considered, particular emphasis being laid on the points of importance to engineers. Three recitations a week. Mr. SCOFIELD.

1226. *MATERIALS LABORATORY.* Required of all Civil Engineering juniors in the four-year curricula. Either term. Credit three hours. Prerequisite course 1138 and must be taken with or preceded by 1225. Experimental determination of the properties of materials by mechanical tests. Study of testing machines (their theory, construction, and manipulation); calibration of testing machines and apparatus; commercial tests of iron and steel; tensile, compressive, torsional, shearing, and flexure tests of metal and various woods with stress-strain observations; tests of cement, concrete aggregate, concrete, plain and reinforced, and of road material and paving brick. The course is planned to supplement Course 1225 with its study of the properties of materials by the actual handling of the materials and by observations of their behavior under stress. Laboratory work five hours a week. Mr. SCOFIELD.

1227. *TESTING OF MATERIALS (LABORATORY).* Given especially for students in the College of Architecture. Any term. Credit one hour. A brief course in laboratory methods comprising tests of beams and columns in steel, wood, and concrete. Mr. SCOFIELD.

MECHANICS OF ENGINEERING

1131. *MECHANICS OF ENGINEERING — STATICS.* Required of all Civil Engineering students in the five-year curriculum. Credit three hours. Prerequisite, Mathematics 60b. Statics of a material point and of rigid bodies and structures by algebraic and graphic methods of analysis, chains and cords, centers of gravity and moments of inertia. Three recitations a week. Textbook: *Analytical Mechanics for Engineers,* Seeley and Ensign. Messrs. HOWELL, ANTONI, and CHENEY.

1132. *MECHANICS OF ENGINEERING—DYNAMICS.* Required of all Civil Engineering students in the five-year curriculum. Credit three hours. Prerequisite 1131. Centrifugal and centripetal forces; dynamics of a particle and rigid bodies; pendulums; friction, work, and power; work and energy; impact, impulse, and momentum. Facility in the use of the slide rule is required. Two recitations and one computing period a week. Textbook: *Analytical Mechanics for Engineers,* Seeley and Ensign. Messrs. HOWELL, ANTONI, and CHENEY.

1133. *MECHANICS OF ENGINEERING—STRENGTH OF MATERIALS.* Required of all Civil Engineering students in the five-year curriculum. Credit three hours. Prerequisite, 1132. Mechanics of materials including stress and strain, tension, shearing, compression, torsion, flexure. Two recitations and one computing period a week. Textbook: *Mechanics of Materials,* George, Rettger, and Howell. Messrs. HOWELL, ANTONI, and CHENEY.

1134. *MECHANICS OF ENGINEERING—STRENGTH OF MATERIALS.* Required of all Civil Engineering students in the five-year curriculum. Credit three hours. A continuation of course 1133. Elastic curves, safe loads, columns, flexure of beams. Problems showing the application of Engineering Design. Two recitations and one computing period a week. Textbook: *Mechanics of Materials,* George, Rettger, and Howell. Messrs. HOWELL, ANTONI, and CHENEY.

1136. *MECHANICS OF ENGINEERING.* Required of all Civil Engineering sophomores in the four-year curricula. Any term. Credit five hours. Prerequisite course, Mathematics 55b. (See course 1137 below.) Statics of a material point and of rigid bodies and structures by algebraic and by graphic methods of analysis; chains and cords; centers of gravity; moments of inertia; kinetics and dynamics of a material particle; centrifugal and centripetal forces; dynamics of collections of material particles forming rigid bodies; pendulums; friction, work, power, measurement of power; the general theorem of work and energy applied to collections of rigid members forming machines; impact, impulse, and momentum. Emphasis is placed upon the theory as well as upon the use of consistent units and correct numerical work. Facility in the use of the slide rule is essential. Textbook: Seeley and Ensign, *Analytical Mechanics for Engineers.* Five recitations a week. Messrs. HOWELL, ANTONI, CHENEY, and JUNCOSA.

1137. *MECHANICS COMPUTATIONS.* Required of Civil Engineering sophomores in the four-year curricula. Any term. Credit one hour. To be taken with Course 1136. Devoted to the solution of problems related to the topics covered concurrently in Course 1136. One computation period of two and one-half hours a week under instruction. Messrs HOWELL, ANTONI, CHENEY, and JUNCOSA.

1138. *MECHANICS OF ENGINEERING.* Required of Civil Engineering sophomores in the four-year curricula. Any term. Credit four hours. Continuation of Mechanics 1136. Prerequisite course, Mechanics 1136. Mechanics of materials including stress and strain, tension, shearing, compression, torsion, flexure; elastic curves; safe loads; columns; flexure of beams by semigraphic treatment. Review problems showing application of principles in Engineering Design. Textbook: George and Rettger, *Mechanics of Materials.* Four recitations a week. Messrs. HOWELL, ANTONI, and CHENEY.

1139. *MECHANICS COMPUTATIONS.* Required of Civil Engineering sophomores in the four-year curricula. Any term. Credit one hour. Courses 1138 and 1139 are closely correlated and should be taken concurrently. One 2½-hour period a week. Messrs. HOWELL, ANTONI, and CHENEY.

1140. *ADVANCED MECHANICS.* Elective. Seniors and graduates. Any term. Credit three hours. Prerequisites, courses 1136 and 1138. Following a brief general review of fundamental topics in Mechanics of Materials, this course covers induced stresses; torsion, unsymmetrical bending; torsion of prisms of non-circular section; hoops; flat plates; localized stresses; theory of least work; internal work and its derivations. Textbook: Seeley, *Advanced Mechanics of Materials.* Recitations, three hours a week. Mr. HOWELL.

MUNICIPAL AND SANITARY ENGINEERING

2501. *SANITARY ENGINEERING.* Required of all students in the five-year curriculum. Credit three hours. Recitations and lectures. The fields of chemistry and bacteriology, and bacteriological technique are covered, special attention being given to the methods of examination of public water and milk supplies, swimming pools and bathing beaches, domestic and industrial wastes, and to the interpretation of such examinations. Three recitations a week. Messrs. WALKER and GIFFT.

2502. *WATER SUPPLY.* Required of all students in Civil Engineering. Credit three hours. Prerequisite course 2351. Sources of water supply, quantity available, uses, and rates of demand. Quality, examination, treatment, and purification. Collection, storage, pumping, and distribution systems. Laboratory periods will include examination and reports on water supply systems, simple design problems, and cost estimates. Textbook: *Water Supply Engineering*, Babbitt and Doland. Two recitations and one computing period a week. Messrs. WALKER and GIFFT.

2503. *SEWERAGE AND SEWAGE TREATMENT.* Required of all students in Civil Engineering. Elective for Chemical Engineering students and for others having prerequisite training. Either term. Credit three hours. Prerequisite, course 2351. The design of sanitary and of storm sewers, and the methods of treating sewage are considered in the recitations; and in the computing period, problems are assigned dealing with design and operation and with subject matter considered in recitation and class-room work. The problems are largely of the nature of separate designs. Textbook: Metcalf and Eddy's *Sewerage and Sewage Treatment.* Two recitations and one computing period a week. Messrs. WALKER and GIFFT.

2504. *SANITARY BIOLOGY.* Elective for Chemical Engineers and for juniors, seniors, and graduates in Civil Engineering. First term. Credit three hours. The course is designed to familiarize the student with the use of the microscope, preparation of media, bacteriological analyses of water, sewage, sewage effluents, and sewage sludge; the preparation and use of stains; disinfection of sewage and of swimming pools. Textbook: Buchanan's *Bacteriology.* One recitation and two laboratories a week. Messrs. WALKER and GIFFT.

2505. *SANITARY BIOLOGY.* Elective for Chemical Engineers and for juniors, seniors, and graduates in Civil Engineering. Second term. Credit two hours. The subject matter covered in the course includes the collection, identification, and control of the various forms of plant and animal life most prevalent in water supplies, and associated with sewage wastes and industrial waste-polluted streams. Consideration is given to the making of biological counts and to the use of biological forms of life as indices of pollution. Various references and texts are used in the course. One recitation or lecture and one laboratory a week. Mr. WALKER.

2506. *ADVANCED WATER SUPPLY.* Elective for seniors and graduates. Second term. Credit three hours. Prerequisite, course 2502. This course comprises a comprehensive study of the general principles and methods involved in furnishing safe water supplies of satisfactory quality. The topics studied include the character of surface and underground water supplies; inspection of sources; relation of communicable diseases to water supplies; standards of quality and examination procedures to determine quality and safety of supplies; water treatment methods including coagulation, sedimentation, aeration, slow and rapid sand filtration, tastes and odor control, softening and iron removal, corrosion control, sterilization, and miscellaneous treatment methods. Also some study of design and operation of water treatment plants is included. Two recitations and one computation period a week. Messrs. WALKER and GIFFT.

2507. *ADVANCED SEWERAGE WORKS.* Elective for seniors and graduates. First term. Credit three hours. Prerequisite, course 2503. A comprehensive study of principles and methods involved in the design, construction, and operation of sewers and sewage treatment works, including reference to existing typical plants. In general, the study includes the determination of capacity and design of sewers; the disposal of sewage by dilution or broad irrigation; stream pollution and self-purification; sewage treatment methods, including preparatory devices, sedimentation, chemical precipitation, intermittent sand, and trickling filters, activated sludge,

sludge digestion, sludge dewatering and incineration, and miscellaneous treatment methods. Textbook: Metcalf and Eddy, *American Sewerage Practice, Vol. III, Disposal of Sewage*. Two recitations and one computation period a week. Messrs. WALKER and GIFFT.

2508. *TREATMENT OF WASTES*. Elective for seniors and graduates in Civil Engineering and for Chemical Engineers. First term. Credit three hours. Prerequisite, course 2503. The treatment of municipal and industrial wastes such as garbage, and the wastes from tanneries, packing-houses, mines, canning factories, textile mills, paper and pulp mills, creameries, cheese factories, condensaries, breweries, sugar refineries, etc. Flow or process charts are used to show the general character of the waste, and methods of treatment applicable are considered. Special attention is given to experimental studies of waste treatment, and to plant-scale treatment. Numerous references, bulletins, reports. Three lectures or recitations a week. Mr. WALKER.

2509. *PUBLIC HEALTH ENGINEERING*. Elective for seniors and graduates. Second term. Credit three hours. A study of the place of the engineer in public health work. Organization and operation of Boards of Health; mosquito abatement, epidemiology and vital statistics, public health laws, and the sanitary code. Three lecture or recitation periods a week.

2510. *RURAL SANITATION*. Elective for juniors, seniors, and graduates. Second term. Credit two hours. A course dealing with the sanitation of rural areas; trailer, construction, military, recreational, and other camps, summer hotels, and swimming pools; the inspection of municipal or public water supplies, sewerage systems; and sewage treatment plants, garbage treatment plants, restaurants and the rating of water supply and milk sheds. Attention is given to water supply, sewage and garbage disposal, and to the problem of milk sanitation. Lectures, reports, and recitations. Two periods a week. Mr. WALKER.

2511. *WATER AND SEWAGE ANALYSIS*. Elective for juniors and seniors. First term. Credit two hours. The purpose of the course is to acquaint the student with the standard procedures followed in making physical and chemical analyses of water and of sewage. Textbooks: *Standard Methods of Water Analysis, A.P.H.A., Water and Sewage Analysis,* Eldrige, Theroux, and Mallman. Two laboratory periods a week with lectures, recitations, and laboratory work. Messrs. WALKER and GIFFT.

2512. *A LABORATORY COURSE FOR GRADUATES*. Hours to be arranged. A course devoted to some problem of water or sewage or trade waste, such as the operation of a water filtration plant, a sewage disposal plant, the detection, measurement, and treatment of trade wastes, the value of disinfection, etc. Mr. WALKER.

2541. *SANITARY ENGINEERING DESIGN*. Either term. Credit three hours. This course should be preceded by Courses 2502 and 2503, or equivalent courses. The purpose of the course is to teach methods of determining the capacity, basis of design, computations, sketches, and general plans and profiles involved in the design of sewerage, trade waste, and water treatment works. Problems may be elected such as the design of a separate or combined sewerage system, an intercepting sewer, a municipal or an institutional sewage treatment plant, a plant for the treatment or disposal of an industrial waste, or a plant for the treatment of an industrial, institutional, or municipal water supply. Messrs. WALKER and GIFFT.

2542. *SANITARY ENGINEERING RESEARCH*. Either term. Prerequisites for work in this field will depend upon the particular problem to be pursued, but in general will include work in water analysis, bacteriology, and courses in Hydraulics and Sanitary Engineering dealing with the field in which the work is to be under-

taken. Hours, credit for work, prerequisites, and other questions relating to contemplated research in this field will be arranged by conference. Messrs. WALKER and GIFFT.

2543. *SANITARY ENGINEERING SEMINAR.* One to six hours credit. Elective. Open to specially selected seniors or graduate students. Abstraction and discussion of technical papers and publications in the sanitary field. One one-hour period a week for each credit hour.

REGIONAL AND CITY PLANNING

(By cooperation of the College of Architecture)

710. *PRINCIPLES OF REGIONAL AND CITY PLANNING.* Elective. Registration limited to 50. Open to graduates and upperclassmen in all colleges of the University. First term. Credit three hours. The history of the planning of communities, including provisions for housing from ancient times to the present. A review of the basic influences in the development of cities. A general view of the theory and accepted practice of city and regional planning including a study of the social, economic, and legal phases. Occasional lectures may be given by members of other faculties and by outside lecturers selected because of their special experience and skill in certain phases of planning. Lectures, assigned reading, and examinations. M W F 12. *White* 201. Messrs. CLARKE and MACKESEY.

711. *CITY PLANNING PRACTICE.* Elective. Second term. Credit three hours. Prerequisite, course 710. The precedures and techniques of gathering and analyzing data for municipal planning studies. The selection and integration of data for use in planning. Practical application of the theories of city planning. Office practice. Lectures, assigned reading reports. M W F 12. *White* 201. Messrs. CLARKE and MACKESEY of the College of Architecture.

712. *REGIONAL PLANNING PRACTICE.* Elective. Open to graduates and upperclassmen in all colleges of the University. Second term. Credit three hours. Prerequisite Course 710. A study of the principles involved in county, regional, state, and national planning. Includes discussion of following factors involved: land use, water resources, recreation, transportation, public services, and public works. Occasional lectures will be given by members of other faculties and outside lecturers. Lectures, assigned reading, reports, and examinations. Hours to be arranged. Mr. CLARKE and Mr. MACKESEY of the College of Architecture.

713. *HOUSING.* Elective. Registration limited. First term. Credit two hours. Prerequisite course 710. An introduction to the theory and standards of housing practice through analysis and comparison of various existing examples, considering the social, economic, and technical sides of the work. Students in the College of Architecture will take one or more design programs having some phase of housing as subject. These problems will be substituted for a regular problem in courses 113 or 151, and values, as earned, will be awarded in those courses. Lectures, assigned reading, and reports. Hours to be arranged. *White* 210. Mr. CLARKE and Mr. MACKESEY of the College of Architecture.

714. *SEMINAR IN REGIONAL AND CITY PLANNING.* Elective. Throughout the year. Credit one hour each term. This course should accompany or follow course 710. Registration limited. Open to students in all colleges of the University, by permission. Investigation of assigned topics on particular aspects of the subject with emphasis on either urban or regional planning. Hours to be arranged. *White, Architectural Seminar Room.* Mr. CLARKE and Mr. MACKESEY of the College of Architecture.

715. *SEMINAR IN PARK PLANNING.* Elective. Registration limited. Open to upperclassmen and graduates in the Colleges of Architecture and Engineering and others by special permission. First term. Credit two hours. Specific problems relating to the design of city, state, and national parks with a study of examples. T 8–10. *White* B–15. Mr. CLARKE (Not given in 1946–1947).

716. *SEMINAR IN PARKWAY, FREEWAY, AND HIGHWAY PLANNING.* Elective. Registration limited. Open to upperclassmen and graduates in the Colleges of Architecture and Engineering. Second term. Credit two hours. Specific problems relating to the design of the modern parkway, freeway, and highway with a study of examples. T 8–10. *White* B–15. Mr. CLARKE.

717. *ZONING PRINCIPLES AND PRACTICE.* Open to graduates and upperclassmen in all colleges of the University. Second term. Credit two hours. Prerequisite, course 710. Technical and legal aspects of drafting and administering zoning regulations. Hours to be arranged. Mr. MACKESEY.

STRUCTURAL ENGINEERING

2701. *STRESS ANALYSIS.* Required of all students in the five-year curriculum. Credit three hours. Prerequisite: Course 1134. Fundamental principles of graphic statics applied to the analysis of beams and trusses. Analytical computation of stresses caused by dead load, moving live loads, impact, and wind load in the principal types of simple highway and railway truss bridges, and in girder bridges. Use of influence lines in the analysis of a three-hinged, spandrel-braced arch. Text: *Stresses in Simple Structures,* Urquhart and O'Rourke. Messrs. O'ROURKE, BURROWS, GRISET, MAINS, and ANTONI.

2702. *STRUCTURAL DESIGN.* (Steel) Required of all students in Civil Engineering. Either term. Credit three hours. Prerequisite, course 2701. An elementary course in steel design. Principles of both riveted and welded connections. Complete designs and detail drawings of the steel skeleton of a small building, including trusses, and of a through plate girder bridge. Textbook: Grinter's *Design of Modern Steel Structures.* Three computation or drawing periods a week. Messrs. O'ROURKE, BURROWS, GRISET, and GILFOYLE.

2703. *TIMBER DESIGN.* Required of all students in the five-year curriculum. Credit two hours. Prerequisite 2701. Design of a timber roof truss of English type, using dimension timbers and framed joints. Design of a two-story industrial building; the second floor is of mill construction supported on interior and exterior columns, and the roof framing consists of flat-top trusses of the Pratt type with built-up members and timber-connector joints. Discussions of grading and preservation of timber. Text: *Modern Timber Design,* Hansen, and miscellaneous commercial data sheets. Two laboratory periods a week. Mr. BURROWS.

2704. *ADVANCED STRESS ANALYSIS.* Required of all Civil Engineering students in the five-year curriculum. Credit three hours. Prerequisites 2702 and 2715. Deflections of beams and statically indeterminate framed structures. Application of the principles of slope-deflection and moment distribution to the analysis of rigid frames, including frames with sidesway and frames with members of varying cross section. Use of influence lines in the analysis of a two-hinged spandrel-braced arch. Text: *Analysis of Statically Indeterminate Structures,* Williams. Three recitations a week. Messrs. O'ROURKE, GRISET, and MAINS.

2705. *ADVANCED STRUCTURAL ANALYSIS* Elective for seniors and graduates and required of seniors in the Structural Engineering Option in Civil Engineering and of all graduate students majoring or minoring in structural engineering. Either

term. Credit three hours. Prerequisite, course 2701. Stress analysis of continuous beams, framed bents, and rigid frames. Horizontal as well as vertical loading considered. Redundant structures including the braced two-hinged arch. Displacement diagrams for trusses and arches and analytical computation of deflections of such structures. Textbook: *Analysis of Statically Indeterminate Structures,* Williams. Three recitations a week. Messrs. O'ROURKE, GRISET, and MAINS.

2706. *STEEL BUILDINGS.* Elective. Seniors and graduates. Any term. Credit three hours. Prerequisites, course 2702. This course comprises the design of the steel framework for buildings of the prevailing type used in power house or shop construction. Dead, snow, and wind stress diagrams are drawn for the roof trusses. Provision is made for an electric crane moving the full length of the building and the stresses in the frame work due to the movement of the crane are determined. The effect of the wind and the eccentric load due to the crane girder are considered in the design of the columns. Textbook: Ketchum's *Steel Mill Buildings.* Reports and drawings. Three two-hour periods a week. Mr. BURROWS.

2707. *BRIDGE DESIGN.* Elective. Seniors and graduates. Second term. Credit three hours. Prerequisite, course 2702. Computations and drawings for the complete design of a railroad bridge of six or seven panels or a heavy highway bridge. The computations to determine the stresses and sections of all members, pins, pinplates, splices, deflection, camber, and other details as well as of connecting rivets are to be written up in the form of systematically arranged reports. The drawings consist of general detail plans showing the location of all rivets as well as the composition and relation of all members and connections. The final report is to give a full list of shapes and plates, and a classified analysis of weight for the span. Textbook: Johnson, Bryan & Turneaure, *Modern Framed Structures, Vol. III.* Computation and drawing, three two-hour periods a week. Mr. BURROWS.

2708. *INVESTIGATION OF EXISTING BRIDGES.* Elective. Seniors and graduates. Second term. Credit three hours. Prerequisite, course 2702. Inspection of existing structures for the determination of sizes and conditions of plates and shapes. After full data have been obtained in the field, computations will be made to determine either the unit stresses under a specified load, or the safe load or rating according to standard specifications. Hours as assigned. Mr. BURROWS.

2709. *RIGID FRAMES IN STEEL OR CONCRETE.* Elective. Credit three hours. Prerequisite 2704. Slope deflection and moment distribution applied to rectangular bents, trapezoidal bents, gable bents, and hip bents. Bents with members of variable moment of inertia. Design of joints. Application to design of rigid frame bridge in steel or concrete. Messrs. O'ROURKE and BURROWS.

2710. *ADVANCED STRUCTURAL THEORY.* Elective. Credit three hours. First term. Prerequisite 2705. Two- and three-dimensional stress. Strength theories. Strain energy methods. Impact stresses. Stress concentration. Design for fatigue. Stresses beyond the elastic limit. Ultimate design in steel and reinforced concrete. Three recitations a week. Mr. WINTER.

2711. *ADVANCED STRUCTURAL THEORY.* Elective. Credit three hours. Second term. Prerequisite 2710 and Math. 200. Design of structural members involving elastic stability. Columns with initial crookedness and eccentric loading. Columns of variable cross-section and open web columns. Lateral strength of beams. Buckling of plates. Design of thin-walled steel structures. Three recitations a week. Mr. WINTER.

2712. *TANKS AND BINS.* Prerequisites, 2705, and Math 200. Theory of plates and shells as applied to the design of reinforced concrete and steel tanks, reservoirs, bunkers, and bins. Three recitations a week. Mr. WINTER.

2715. *CONCRETE CONSTRUCTION.* Required of all Civil Engineering students. Either term. Credit three hours. Prerequisite 1134 or 1138. (Preferably taken concurrently with or preceded by course 1225.) Properties of plain concrete, elementary theory of reinforced concrete as applied to rectangular beams, slabs, T-beams, beams reinforced for compression, columns, and footings. Shear, diagonal tension, and direct stress combined with flexure. Computations in the forms of reports on the design of a typical beam and girder floor panel and of a retaining wall. Detail sketches of sections and reinforcement required. Textbook: Urquhart and O'Rourke's *Design of Concrete Structures.* Six hours a week. Messrs. O'ROURKE, WINTER, GRISET, ANTONI, and MAINS.

2716. *REINFORCED CONCRETE DESIGN.* Elective for seniors and graduates and required for seniors in the Structural Engineering Option in Civil Engineering. Either term. Credit three hours. Prerequisite, course 2715. Design of footings: single and multiple columns of reinforced concrete, I-beam grillages. Design of bins and tanks, subsurface and supported on towers. Design of a highway bridge. Reports and sketches. Three two and one half hour periods a week. Messrs. O'ROURKE and GRISET.

2717. *FIXED ARCHES.* Elective for seniors and graduates and required for seniors in the Structural Engineering Option in Civil Engineering. First term. Credit three hours. Prerequisites, courses 2702 and 2715. Theory of the curved beam; the closed ring; the fixed arch. Influence lines for arches of various forms. Selection of curvature of axis for various loadings. Effect of temperature and rib-shortening. Effect of plastic flow on stresses in a reinforced concrete arch. Design of a reinforced arch and its abutments. Lectures, recitations, and computations. Six hours a week. Mr. O'ROURKE.

2718. *HIGHWAY BRIDGES.* Elective. Seniors and graduates. This course or course 2707 is required for seniors in the Structural Engineering Option in Civil Engineering. Second term. Credit three hours. Prerequisite, course 2715. Design of short span bridges and their abutments. Comparison of the economy of steel and reinforced concrete superstructures for bridges of this type. Reports and drawings. Mr. O'ROURKE.

2719. *REINFORCED CONCRETE BUILDING DESIGN.* Elective. Seniors and graduates. Either term. Credit three hours. Prerequisites, course 2715. Design of a reinforced concrete flat-slab building and investigation of various other types of floor systems for commercial buildings. Complete detail design for one building, including stairway, elevator shafts, penthouses, etc. Working drawings and steel schedules. Textbook: Urquhart and O'Rourke's *Design of Concrete Structures.* Seven and one-half hours a week. Mr. O'ROURKE.

2720. *FOUNDATIONS.* Required of all Civil Engineering juniors or seniors. Either term. Credit three hours. Prerequisite, course 1134 or 1138. Piles and pile driving, including timber, concrete, tubular and sheet piles; cofferdams; box and open caissons, pneumatic caissons for bridges and buildings, caisson sinking, and physiological effects of compressed air; pier foundations in open wells; freezing process; hydraulic caissons; ordinary bridge piers; cylinders and pivot-piers; bridge abutments; spread footings for building foundations; underpinning buildings; subterranean explorations; unit loads. Textbook: Jacoby and Davis's *Foundations of Bridges and Buildings.* Recitations, collateral reading in engineering periodicals, and illustrated reports. Three hours a week. Messrs. O'ROURKE, WINTER, and MAINS.

2721. *ELASTIC FOUNDATIONS AND THIN STRUCTURAL SHELLS.* Elective. Primarily for graduate students. First term. Credit three hours. Study of the properties of elastic foundations and the application of the elastic foundation theory to the

analysis of large diameter, low head tanks, hemispherical domes, hemispherical leaders on large pipes, and thin shell pipes under flexure. Three hours a week.

2723. *SUSPENSION BRIDGE THEORY.* Credit three hours. Prerequisites, 2704 and Math 200 (or equivalent). The elastic theory; stresses in cables, moments and shears in stiffening trusses, temperature effects, and deflections. Fundamental principles of the deflection theory. Three recitations a week. Mr. O'ROURKE.

2725. *SOIL MECHANICS.* Required of all students in Civil Engineering. Either term. Credit three hours. A comprehensive study of the properties of soil, presenting a conception of its behavior as an engineering material. Theory of soil classification, soil structure, pressure distribution, compressibility, cohesion, elasticity, plasticity, and permeability. Laboratory tests for identification of soils; mechanical analysis, determination of water content, specific gravity, density, permeability, etc. Tests for physical properties of soils. Two lectures and one laboratory period a week. Messrs. O'ROURKE and JENKINS.

2726. *APPLIED SOIL MECHANICS.* Elective for seniors and graduate students. Second term. Credit three hours. Prerequisite, course 2725. Advanced application of soil mechanics, based on the principles and physical studies of course 2725. The plastic flow theory; the consolidation theory; stability of earth slopes; flow of water through earth structures; theories of earth pressure on retaining walls, caissons, and tunnels. Review of modern soil mechanics research.

2731. *ELEMENTS OF STRUCTURAL ENGINEERING.* Elective. Seniors in Electrical Engineering. Any term. Credit two hours. Analysis and design of beams of steel, timber, and concrete, columns, footings, and retaining walls. Textbook: Urquhart & O'Rourke's *Elementary Structural Engineering.* One lecture and one computing period a week. Mr. GRISET.

2741. *STRUCTURAL ENGINEERING DESIGN.* Either term. Prerequisite, courses 2702, and 2715. The student may select a problem such as the following: (a) an arch bridge of steel, (b) a cantilever bridge, (c) a rigid frame bridge, (d) a special problem in steel or concrete building design, (e) the design of any other structure of particular interest to the student provided he has had the proper preparation for such design. The work is submitted in the form of reports. Drawings of typical details must accompany reports. Messrs. O'ROURKE, BURROWS, and others.

2742. *STRUCTURAL ENGINEERING RESEARCH.* Any term. Students wishing to pursue one particular branch of bridge engineering further than can be done in any of the regular courses may elect work in this field. The prerequisite courses depend upon the nature of the work desired. The work may be in the nature of an investigation of existing types of construction or theoretical work with a view to simplifying present methods of design or proposing new methods. Messrs. O'ROURKE and BURROWS.

2743. *STRUCTURAL ENGINEERING SEMINAR.* One to six hours credit. Elective. Open to specially selected seniors or graduate students. Abstraction and discussion of technical papers and publications in the structural field.

2751. *STRESS ANALYSIS AND STRUCTURAL DESIGN.* Required of all juniors in Civil Engineering in the 4-year curricula. Either term. Credit four hours. Prerequisites, courses 1136 and 1138.

STRESS ANALYSIS. Graphic analysis of simple and cantilever beams, roof trusses, and framed bents. Determination of position of moving concentrated loads for maximum shears and moments in beams and deck girders; also for through girders and maximum floor beam reactions for same. Stresses due to dead load, live load, impact,

and wind load in the principal types of simple trusses employed in modern construction. Stiff web systems and counter bracing. Three-hinged roof and bridge arches. Practical problems in actual stress computation throughout the course. Textbook: Urquhart and O'Rourke *Stresses in Simple Structures.* Three recitations a week.

STRUCTURAL DESIGN. Graphic analysis of stresses in a timber truss. Design of truss members and joint details. Computations, systematically arranged in the form of reports, and working drawings. Textbook: Hansen's *Modern Timber Design.* Computation and drawing, two and one-half hours a week. Messrs. O'ROURKE, BURROWS, GRISET, and ANTONI.

2752. *ENGINEERING PROBLEMS.* Required of Civil Engineering seniors in the four-year curricula. Either term. Credit two hours. Prerequisites, courses 1138, 2302, or 2351. The object of this course is to provide a review involving additional practice in using the principles and methods of applied mechanics. A series of problems, such as occur in ordinary engineering practice, and covering a wide range of topics, is given out for solution. Computations and reports. Five hours a week. Messrs. HOWELL, ANTONI, and CHENEY.

SURVEYING.

2101. *ELEMENTARY SURVEYING.* Required of all freshmen in Civil Engineering. First term as assigned. Credit three hours. Use of steel tape, level, and transit; fundamental surveying methods; measurements of lines, angles, and differences of elevation; land surveying, areas and plotting. Textbook: Breed and Hosmer's *Elementary Surveying.* First term, one recitation and two field, computation, or mapping periods a week. Second term, three recitation periods a week for the first six weeks and three field, computation, or mapping periods a week during the remainder of the term. Messrs. UNDERWOOD, LAWRENCE, SPRY, and others.

2102. *ADVANCED SURVEYING.* Required of freshmen in the five-year course. Credit three hours. Prerequisite, Elementary Surveying 2101. City and mine surveying, surveys of the United States public lands; volumetric, topographic, hydrographic, and geodetic surveying; elements of photographic surveying; map projections; elements of practical astronomy. Textbooks: Breed and Hosmer's *Elementary Surveying, Volume I,* and *Higher Surveying, Volume II.* Three recitations a week. Messrs. UNDERWOOD, LAWRENCE, SPRY, and others.

2103. *SUMMER SURVEY:* (Topographic, Hydrographic, and Geodetic Survey Camp.) Required of all Civil Engineering students, following the sophomore year. Credit five hours. Prerequisite, Advanced Surveying 2102 or 2151. Practical experience in surveying under field conditions. An extensive topographic survey with the transit and stadia and the plane table, and a hydrographic survey of a portion of Cayuta Lake are executed, and field maps are made. Triangulation and precise leveling control the topographic and hydrographic work. A base line is measured with invar tapes. Solar observations for azimuth and time are made and results computed. Each students takes part in all branches of the work. Field and office work six days a week. Attendance for five weeks. Date of beginning of the camp will be announced in the second term. Messrs. UNDERWOOD, LAWRENCE, PERRY, THATCHER, and SPRY.

2104. *TOPOGRAPHIC SURVEYING AND MAPPING.* Elective for Upperclassmen and graduate students. Three hours credit. Prerequisite, course 2103. Methods of making topographic surveys for mapping to large scales. The use of the plane table. Solutions of the three-point problem; the two-point problem; location of details by direction and distance. Mapping, including the construction of a final topographic map of the area covered by the field work of course 2103 during the

preceding summer. Lectures, recitation, field work, and mapping. One lecture and two laboratory periods a week. Mr. UNDERWOOD.

2105. *LEAST SQUARES: ADJUSTMENT OF OBSERVATIONS.* Elective for upperclassmen and graduate students. Either term. Credit three hours. Prerequisites, Calculus and Physics. The course is designed for students who have experimental investigations in view. The fundamental principles of least squares with application to the adjustment of typical surveying work, such as leveling and triangulation. Applications are also made to problems in physics, astronomy, mechanics, etc., with some attention to the derivation of empirical formulae. Textbook: Leland's *Practical Least Squares.* Lectures, recitations, and laboratory periods, three a week as may be arranged. Mr. UNDERWOOD.

2106. *ADVANCED TOPOGRAPHIC SURVEYING.* Elective. Upperclassmen. Second term. Credit two hours. Prerequisite, course 2103. Economics of surveying methods. Surveys for special purposes, such as extensive construction work, and storage distribution of water for irrigation; earthwork on a large scale, lines of communication, topographic reconnaissance, etc.; photographic surveying. Lectures, recitations, and assigned readings. Mr. UNDERWOOD.

2107. *GEODESY AND GEODETIC LABORATORY.* Elective for upperclassmen. Any term. Credit three hours. Prerequisites, course 182 and 2102. A course for the consideration of special problems in geodetic work. Precise leveling, deflection of the plumb line, figure of the earth, use and investigation of geodetic instruments and apparatus such as circles, levels, micrometer microscopes, standards of length, thermometers, pendulums, magnetic apparatus, etc. Subject to arrangement to meet the special needs of students. Lectures, reading, discussions, and laboratory work. Three periods a week. Mr. UNDERWOOD.

2108. *PHOTOGRAPHIC AND AERIAL SURVEYING.* Elective for upperclassmen. Any term. Credit three hours. Prerequisite, Advanced Surveying 2102. The principles of photographic surveying; surveys with camera stations on the ground, including stereoscopic methods; aerial surveys and making of maps from such surveys; ground control. Recitations, lectures, and collateral reading. Three hours a week. Mr. UNDERWOOD.

2109. *MAP PROJECTIONS AND MAPPING.* Elective for upperclassmen and graduate students. Credit three hours. The theory of map projections. Construction of projections. Plane coordinate systems. Map reproduction. Practice in topographic surveying and in mapping. One recitation and two laboratory periods a week. Messrs. UNDERWOOD and LAWRENCE.

2131. *ELEMENTARY SURVEYING.* For students in Mechanical and Electrical Engineering. Either term. Credit one hour. Use of steel tape, level, and transit. Fundamentals. Problems of particular interest to Mechanical and Electrical Engineering. Textbook: *Surveying,* Breed. One 2½-hour period a week. Messrs. UNDERWOOD, LAWRENCE, CRANDALL, PERRY, SPRY, DUNCAN, and assistants.

2132. *ADVANCED SURVEYING.* For students in Landscape Architecture. Second term in alternate years. Credit two hours. Prerequisite, Elementary Surveying 2101. Profile leveling; cross-sectioning; earth-work; circular curves and spirals; vertical curves. Textbook: Breed and Hosmer's Vol. I, *Elementary Surveying.* Recitations, computation, and field work. Mr. LAWRENCE.

2142. (a) *GEODETIC ASTRONOMY.* Any term. Prerequisites, courses Astronomy 186 and 2105. Investigations of instrumental errors; variation of latitude and azimuth; and all questions relating to work of the highest precision connected with astronomical problems and geodetic operations. The field is so broad that the interest of the

student is given consideration as to the actual research undertaken. Mr. UNDERWOOD.

(b) *GEODETIC ENGINEERING RESEARCH.* Either term. Prerequisites will depend upon the line of work to be pursued. Special problems in least squares, reduction of triangulation, and photographic surveying as may be arranged. Mr. UNDERWOOD.

2243. *SEMINAR IN GEODESY.* One to six hours credit. Elective. Open to specially selected seniors or graduate students. Abstraction and discussion of technical papers and publications in the geodetic field.

2151. *SURVEYING.* Required of all Civil Engineering students in lieu of 2103 until June 1947. Summer Surveying. Credit three hours. Prerequisite, Advanced Surveying 2102. Practical experience in the field. Messrs. UNDERWOOD, LAWRENCE, and SPRY.

TRANSPORTATION

2601. *ROUTE SURVEYING AND DRAWING.* Required of all Civil Engineering sophomores. Either term. Credit three hours. Prerequisite, Advanced Surveying 2102. The recitations cover the theory of simple, transition, and vertical curves, and earthwork computations; with applications to practical problems for purposes of illustration. The field periods take up about two-thirds of the term and are devoted to computing, laying out, and checking simple, transition, and vertical curves. The drawing periods take up the remaining third of the term and in them each student makes a pencil map of a preliminary line surveyed in Course 2103 and prepares a detailed "paper location" report based on these data. A tracing and profile of the final location as run in the field is then required, also a computation of part of the earthwork. Textbooks: Pickels & Wiles, *Route Surveying* and Crandall, *Earthwork Tables.* One recitation and two field or drawing periods a week. Messrs. THATCHER, CRANDALL, and PERRY.

2602. *TRANSPORTATION.* Required of Civil Engineering students in the five-year curricula. Elective for seniors and graduates. Second term. Credit three hours. A course covering travel and transport agencies with special reference to their facilities, ownership, financing, regulation, and coordination. A brief review of the development of transportation throughout the world is used as a background for an intensive study of the present situation in the various countries and comparison of the policies and practices in use. Particular attention is given to the various proposals designed to promote more efficient use of the various transportation agencies in the United States by better coordination, pooling of facilities, etc., and economic studies are made of some of the new projects which are under discussion. Lectures and recitations three hours a week. Mr. PERRY.

2603. *RAILROAD MAINTENANCE OF WAY.* Elective. Seniors and graduates. First term. Credit three hours. Prerequisite, course 2601. The subjects treated are track materials (with special reference to the section, method of manufacture, and composition of steel rails, to the economics of tie preservation and the use of metal ties, and to the effect of quality of ballast upon maintenance); machine and other methods of grading for second track; drainage; track laying by both machine and hand methods, ballasting and bringing new track to line and grade; turnouts and switches; derailing switches; side tracks and yard tracks; sorting and terminal yards; track maintenance; track tools, work trains; action of car wheels on curves; widening of gage; double tracking; separation of grades; and improvement in grades and alignment. Textbook: Tratman, *Railway Track and Maintenance.* Lectures and recitations three hours a week. Mr. PERRY.

2604. *RAILROAD OPERATION AND MANAGEMENT.* Elective. Seniors and graduates. Second term. Credit three hours. Prerequisite, course 2601. Under organization, the following subjects are treated: general pinciples underlying organization and the effect of each on efficiency; principal departments of railway service with a brief outline of the work of each; departmental and divisional systems of organization, with examples on various roads and discussion of adaptability of each. The duties of officers and the work of the different departments are taken up in considerable detail. The most important laws affecting railroads are given in discussing the work of the legal department. Freight traffic, freight houses, classification yard, car service rules, accounting, etc., are among the topics considered under operation. Signaling and interlocking and train rules are also considered. Lectures and recitations three hours a week. Mr. PERRY.

2610. *HIGHWAY ENGINEERING.* Required of all Civil Engineering students. Credit three hours. Prerequisite, 2601 and 2725. Design, construction, and maintenance of highways and city streets. Location, alignment, drainage, width, and capacity; soils and soil stabilization; earth, gravel, and macadam roads; city and rural pavements; grade separations; minor structures; construction in swamps; construction methods and equipment; traffic control; planning surveys, economics, financing, and administration. Two recitations and one computing period a week. Textbook: *Highway Design and Construction,* Bruce. Messrs. BELCHER and LEWIS.

2611. *HIGHWAY ENGINEERING.* Required of all seniors in the five-year curriculum. Credit three hours. Survey, sampling and testing of soils and aggregates; bituminous materials. Construction methods: Grading and paving; analysis and correction of characteristic pavement failures; rural and urban traffic problems. Limited access roads and freeways. Special structures and landscaping.

2612. *HIGHWAY LABORATORY.* Elective. Seniors and graduates. Either term. Credit three hours. Prerequisite, course 2610 or may be taken concurrently with course 2610. Non-bituminous and bituminous materials are tested. Subgrade soils are sampled and their properties examined; subgrade stabilization admixtures are also tested and studied. Bituminous mixtures are designed, and their properties examined. Two laboratory periods a week. Mr. BELCHER.

2613. *ADVANCED HIGHWAY LABORATORY.* Elective. Seniors and graduates. Either term. Credit three hours. Prerequisites, courses 2610 and 2611. Non-bituminous and bituminous materials are tested and their characteristics studied. Soils are sampled and examined, and investigations made of the behavior of mixtures of soils with bituminous and non-bituminous materials. Special investigations and tests are made to determine the properties of various combinations of materials and the effects of modifications in design. Two laboratory periods a week. Mr. BELCHER.

2614. *ADVANCED HIGHWAY ENGINEERING.* Elective. Seniors and graduates. Second term. Credit three hours. The topics for assignment and discussion include the economics of highway engineering, highway finance, legislation, regulation, traffic, design, construction, and maintenance of highways, the latest research programs and reports, labor and plant organization for various kinds of highway contracts with especial emphasis on the economics of contracting, etc. This course is conducted as a seminar. Meetings are held once each week at hours to be arranged. Mr. BELCHER.

2615. *MODERN HIGHWAY PLANNING AND DESIGN.* Elective. Seniors and graduate students. Second term. Credit three hours. Prerequisite, course 2610 or its equivalent. Study of geographical, political, and economic divisions of communities with particular reference to highway transportation requirements; analysis of regional plans chiefly concerning the classification of roads and the selection of routes to be abandoned or improved, based upon their economic justification. Design of

regional systems of highways, freeways, and parkways, including the consideration of the economic, safety, and aesthetic aspects. Traffic studies, legislation, financing, and zoning. Design of intersections and grade separations. Problems and reports required. Mr. CLARKE.

2616. *CITY STREETS.* Elective. Seniors and graduate students. Credit two hours. Prerequisite 2610. The location and design of streets in cities and villages. One recitation and one long period a week. Mr. MALCOLM.

2617. *AIRPORTS.* Elective. Seniors and graduate students. Credit three hours. Prerequisite, 2610 and 2725. The location, design, construction, and maintenance of airports. Two recitations and one computing period a week. Mr. MALCOLM.

2618. *LOW COST ROADS.* Elective. Seniors and graduate students. Either term. Credit three hours. Prerequisite, course 2610 or its equivalent. Study of economic importance of routes and selection of farm to market roads to be improved; location and design; subgrade soils and stabilization of subgrade soils by use of admixtures, chemicals, and bituminous materials; drainage and drainage structures; bituminous treatments and bituminous mats for stabilized subgrades. Survey of the experimental work in the use of materials and design and construction of low cost roads. Design, construction, and maintenance of road mixes, plant mixes, etc. Messrs. MALCOLM and BELCHER.

2619. *BITUMINOUS PAVEMENTS.* Elective. Credit three hours. Prerequisite, 2610 and 2612. Part I: Properties of tars; base and liquid asphalts. Weathering and stripping of bituminous films; adhesion. Special uses and applications of individual materials. Part II: Theory and practice in design based on surface area, density, and loading and subgrade conditions. Part III: Design of surface treatment mixes, patches, sheet asphalt, bituminous concrete. Rock asphalt. Control and construction. Bituminous undersealing and maintenance. Mr. BELCHER.

2620. *TRAFFIC ENGINEERING.* Elective. Credit three hours. Prerequisite, 2610. City and highway traffic surveys. Traffic control and routing. Signs and markings. Regulation; truck and bus units as traffic elements. Driver reactions and habit patterns; design of safety features and effectiveness of signs. Also air traffic for those specializing in airports. Three recitations a week. Mr. LEWIS.

2621. *ENGINEERING INTERPRETATION OF AERIAL PHOTOGRAPHS.* Elective. Credit three hours. A study of the soil and rock areas of the United States and the patterns that they present in aerial photographs. Fundamental elements of soil patterns are analyzed to permit determination of soil texture, type of bedrock, and drainage properties. Special emphasis is placed on the interpretation of engineering information dealing with construction, excavation, clearing, water supply, drainage requirements, and foundation problems. Two recitations and one computing period a week. Mr. BELCHER.

2622. *ADVANCED ENGINEERING INTERPRETATION OF AERIAL PHOTOGRAPHS.* Elective. Credit three hours. Prerequisite, 2621. Engineering interpretation of aerial photographs with special emphasis on engineering construction problems in frozen ground (arctic), the analysis, mapping and estimating of tropical areas, and the special problems associated with arid regions. Particular emphasis is placed on the significance of vegetation in these three special climatic areas. Two recitations and one drawing room period a week. Mr. BELCHER.

2641. *TRANSPORTATION ENGINEERING DESIGN*

(a) *RAILROAD ENGINEERING.* Either term. The problems are those encountered in the location and construction of railroads, and include the following sub-

jects: Economic location of railroads; culverts; bridges; retaining walls; tunnel and subway design; small depot buildings; freight houses; water supply and coaling plants; icing stations; turntables and engine-houses; gravel washing plants; track layouts with details of signals and interlocking; yard and terminal design, etc. Bills of material and estimates of cost are usually required. The field is so broad that the interest of the student is given consideration in assigning problems. Mr. PERRY.

(b) *HIGHWAY ENGINEERING.* Either term. The problems are those encountered in the selection, location, design, and construction of highways. They include the following: Economic selection of routes, economic location, design of highways, highway intersections, culverts, highway bridges, retaining walls, and other highway structures. Bills of materials and estimates of cost are usually required, also plant layouts and methods of executing work. Mr. BELCHER.

2642. *TRANSPORTATION ENGINEERING RESEARCH*

(a) *RAILROAD ENGINEERING.* Either term. Special problems in the economics of location, construction, maintenance, and operation of railroads, comparison of transportation agencies, traffic studies, and economics of various systems of transport. Mr. PERRY.

(b) *HIGHWAY ENGINEERING.* Either term. Prerequisites, courses 2610 and 2613. Studies of traffic and traffic regulation and legislation may be made. The field of economics of highway engineering offers a wide variety of problems. Laboratory investigations of subgrade soil, subgrade stabilization, and the effects of modifications in design of bituminous and non-bituminous mixtures provide a wide range of topics for research. Messrs. BELCHER and LEWIS.

2643. *TRANSPORTATION ENGINEERING SEMINAR.* One to six hours credit. Elective. Open to specially selected seniors or graduate students. Abstraction and discussion of technical papers and publications in the transportation field.

SPECIAL AND GRADUATE COURSES

2801. *THESIS.* Elective. Seniors. Either or both terms. Credit three or more hours. The thesis gives the student, desiring to work out a special problem or make an engineering investigation, and to record the result of his work, the opportunity of so doing. Registration for thesis must be approved by the professor in charge at the beginning of the semester during which the work is to be done.

SPECIAL NOTE

All the elective courses are suitable for graduate and advanced students, and may be taken by them in the regular classes. Other special courses will be arranged to suit the requirements of graduate students. These special courses are intended to be pursued under the immediate direction of the professor in charge, the student usually being free from the restriction of the classroom, and working either independently or in conjunction with others taking the same course.

MECHANICAL ENGINEERING

NUMBERING SYSTEM IN THE SCHOOL OF MECHANICAL ENGINEERING. The first digit (3) of the number designates the School of Mechanical Engineering, the second digit indicates the department in the school, and the third and fourth digits

constitute the course numbers within the department. In most cases the old course numbers are retained, the only change being the substitution of the department numbers for the former department letters. The Departments of Industrial Engineering and Administrative Engineering have been combined to form the new Department of Industrial and Engineering Administration, and the Departments of Engineering Materials and Mechanics have become service departments. The courses in Aeronautical Engineering fall under the Graduate School of Aeronautical Engineering. Department numbers (and former letters): O, General (G); 1, Engineering Drawing (C); 2, Industrial and Engineering Administration (A and I); 4, Materials Processing (S); 5, Heat-Power Engineering (P); 6, Mechanical Engineering Laboratory (X); 7, Automotive Engineering (B). The following are the numbers of the service courses: Mechanics, 1100 and up; Engineering Materials, 1200 and up. The courses in Aeronautical Engineering have 7 as the initial digit.

The courses in Mechanical Engineering are listed under the following headings: Automotive Engineering, Drawing and Descriptitve Geometry, Heat-Power Engineering, Industrial and Engineering Administration, Machine Design, Materials of Engineering, Materials Processing, Mechanics of Engineering, Mechanical Engineering Laboratory.

AUTOMOTIVE ENGINEERING

3741. *AUTOMOTIVE LECTURES.* Seniors and graduates. Credit three hours. Three lectures a week. Prerequisite, course 3338. The automobile, and the power required for its operation, but not including the power plant. Analysis is made of the relations of the car to the road; functions of steering, driving, braking; mechanical efficiency of chassis; springing for comfort of riding; wind resistance; layout of parts for balanced design. Mr. OTTO.

3743. *AUTOMOTIVE COMPUTATIONS.* Credit two hours; two computing periods a week. Must be accompanied by course 3741, which it parallels, but with more detailed studies to acquaint students with methods of attack on problems in operation or design. Mr. OTTO.

3744. *AUTOMOTIVE POWER COMPUTATIONS.* Credit two hours. Two computing periods a week. Must be accompanied by 3581, which it parallels, but with more detailed studies in operation and design. Mr. OTTO. (Temporarily discontinued.)

3750. *ADVANCED AUTOMOTIVE ENGINEERING.* Elective for qualified seniors and graduates. Each term. Credit two to five hours as arranged. Selected advanced topics and special problems. Mr. OTTO.

DRAWING AND DESCRIPTIVE GEOMETRY

3111. *DRAWING AND DESCRIPTIVE GEOMETRY.* Each term. Credit three hours. One recitation and two drawing periods a week. Coordinated instruction in subjects prerequisite to a study of the engineering applications of drawing. The drafting arts. Geometric analysis and composition of structures including considerations of the elements of structure and their properties, interspace relations of structural elements, determinants of elements and structural organization along paths of physical and functional ties. Graphic computation and description of the geometric qualities and quantities of structure. Messrs. TOWNSEND, CLEARY, MORDOFF, BAIRD, and instructors. *East Sibley.*

3112. *MECHANICAL DRAFTING.* Each term. Credit three hours. One recitation and two drawing periods a week. Prerequisite, course 3111 and must be taken with

or preceded by courses 3401, 3402 or 3403 and 6111. Studies of mechanical anatomy are coordinated in this course with studies in the three functional divisions of mechanical drafting, namely: (1) the creative division or layout drafting; (2) the expressive division or detail drafting; (3) the interpretation division or blueprint reading. Free-hand sketching, pictorial drawing, tracing, etc., are studied as applied in this work. Messrs. TOWNSEND, CLEARY, MORDOFF, BAIRD, and instructors.

3114, 3115. *DRAWING.* For students in Chemical Engineering. Two terms. Credit two hours a term. One recitation and one drawing period a week. A brief course in the basic subjects of drawing and the techniques of applying these subjects to the determination of structure by layouts and the specification of structure on working drawings. Messrs. TOWNSEND, CLEARY, SIEGFRIED, and instructors.

3116. *FREEHAND AND PERSPECTIVE DRAWING.* Elecitve. Credit two hours. Freehand sketching, parallel projection, perspective drawing, with engineering application. Production illustration. Offered only when there is sufficient demand for the course and conditions permit giving it. Mr. BAIRD.

HEAT-POWER ENGINEERING

3530. *THERMODYNAMICS.* For students in Electrical Engineering. Three recitations a week. Credit three hours. Prerequisites, Physics and Mechanics. The fundamental concepts and principles involved in the release, transfer, and conversion of thermal energy. Energy concepts and units; energy equations. Properties of gases, vapors, and mixtures. Expansion and compression of fluids. The use of Thermodynamic tables and charts. Messrs. GAY and WATT.

3531. *HEAT-POWER.* For students in Electrical Engineering. Credit two hours. Two recitations a week. Prerequisite 3530 or its equivalent. Fuels, combustion, steam-generating units, steam turbines, condensers, internal combustion engines and performances of complete power plants. Messrs. GAY and WATT.

3532. *HEAT-POWER.* One laboratory period a week taken with 3531. Credit one hour.

3535. *HEAT-POWER ENGINEERING.* Credit three hours. Prerequisites, 3325, 3326, 1111, and 1112, or their equivalent. Three recitations a week. Basic thermodynamics of gases and vapors; ideal cycles and their application in air compressors, internal combustion engines, steam engines, and turbines; efficiencies and performances. Messrs. HOOK, CLARK, and CONTA.

3536. *HEAT-POWER ENGINEERING.* Credit three hours. Prerequisite, 3535 or its equivalent. Three recitations a week. Flow of fluids through nozzles, orifices, and turbines; steam-turbine types, and their applications; heat transfer; condensers; fuels; combustion; steam-generation units; exit gas analysis; furnaces; boilers; stokers; and other fuel-burning equipment. Messrs. ELLENWOOD, CLARK, and CONTA.

3543. *HEAT-POWER ENGINEERING.* Required of all seniors in Civil Engineering. Alternate terms. Credit three hours. Not open to students in Mechanical or Electrical Engineering. Prerequisite courses, Physics (or the equivalent), Chemistry, and Mechanics. Two lectures and one two-hour period used for laboratory, inspection, computing, or quiz purposes. Basic consideration of the behavior of gases and vapors as applied to heat engines; also the operation, maintenance, application, performance, first cost, and operation cost of air compressors, compressed-air equipment, internal combustion engines of both the carburetor and the compression-ignition types, steam boilers, engines, and turbines. Mr. WATT.

3544, 3545. *STEAM AND OIL ENGINE POWER PLANTS.* Two lectures a week. Two terms. Credit two hours a term. Prerequisite courses, 3337, 3332, 3535, and 3536; must be accompanied by courses 3546 and 3547, and accompanied or preceded by courses 3581 and 3582. Performance characteristics and design features of steam prime movers, steam generators, condensers, feedwater heaters, evaporators, deaerators, oil engines, pumps, fans, and cooling towers; power-plant piping; automatic control; power-plant instruments, fuel-burning equipment; coal- and ash-handling equipment. (Temporarily discontinued.)

3546, 3547. *POWER PLANT COMPUTING AND DESIGN.* Two computing periods a week. Credit two hours a term. Must be accompanied by 3544 and 3545. Energy balances; plant layouts; piping layouts; selection of equipment for central stations and industrial power plants. (Temporarily discontinued.)

3548. *HEATING, VENTILATING, AND AIR CONDITIONING.* Required of all seniors in Mechanical Engineering except those electing Option B. Any term. Credit three hours. Principles and practice in the conditioning of air, including cooling, heating, dehumidifying, and ventilating. Mr. MACKEY. (Temporarily discontinued.)

3550. *POWER PLANT ECONOMICS: EQUIPMENT SELECTION.* Elective for seniors. Alternate terms. Credit two hours. Prerequisite courses 3535, 3536. Two lectures a week. Cost of equipment and plants; energy costs; load curves, station factors; determining characteristics of equipment: selection of working pressures and temperatures and cycles; proper load distribution; economic number and sizes of units; selection of equipment based on these and other determining considerations; economic operations. Application to central stations and to industrial power and heating plants. Other similar topics. (Temporarily discontinued.)

3551. *STEAM TURBINES.* Elective for seniors. Alternate terms. Credit two hours. Prerequisite, courses 3535, 3536, or equivalent. Two lectures a week. Classification of turbines and description of leading features of the various types; mechanical and thermal considerations underlying the action of steam in turbines; calculations involved in turbine design; discussion of building, erecting, and testing; adaptability to special conditions of service; economic results of the use of turbines in engineering practice. Mr. CLARK.

3557, 3558. *HEAT-ENGINEERING.* Throughout the year. Credit four hours a term. Must be accompanied or preceded by 3582. Properties of mixtures, dimensional analysis, fluid flow, heat transmission, selection of fans and pumps, and refrigeration; applications to problems in air conditioning. Mr. MACKEY. (Temporarily discontinued.)

3563. *ADVANCED THERMODYNAMICS.* Elective for advanced students. Alternate terms. Credit two hours. Two recitations a week. Prerequisites: 3535 and 3536. The Carnot Principle; temperature scales; entropy; the state properties of a substance, their experimental determination and correlation; equations of state, kinetic theory of gases; mixtures of ideal gases; special topics in mathematics will be considered as needed. Mr. CONTA.

3570. *ADVANCED HEAT-POWER ENGINEERING RESEARCH.* Elective for graduate students and others qualified for advanced study in this field. Work and credit as arranged with Mr. ELLENWOOD and others of the department.

3581. *INTERNAL COMBUSTION ENGINES.* Required of all seniors in Mechanical Engineering. Credit three hours. Prerequisites, 3535 and 3536, or their equivalent. The fundamentals of internal combustion engines with emphasis on thermodynamics and the combustion process. Both spark-ignition and compression-ignition engines

are considered and topics studied include air standard cycles, the combustion process, ideal cycles of air-fuel mixtures, deviations from ideal processes, performance of actual engines, fuels and fuel supply systems, ignition of the charge, and mechanical details. Messrs. CONTA and GAY.

3582. *STEAM-POWER PLANTS.* Credit three hours. Required of all students in Mechanical Engineering. Prerequisites, 3535, 3536, or their equivalent. A review of the thermodynamics of vapors is followed by a further study of combustion and combustion-control equipment, draft apparatus; boilers, condensers, evaporators, feedwater heaters, feed pumps, economizers, and air preheaters; turbines, and plant auxiliaries; performance and cost of steam engines, turbines, and plants. Messrs. ELLENWOOD and CLARK.

3588. *REFRIGERATION AND AIR CONDITIONING.* Required of all seniors in Mechanical Engineering. Two recitations and one laboratory period a week. Credit three hours. Prerequisites, 3535, 3536, or their equivalent. The general principles of refrigeration with particular emphasis on the equipment; principles and practice in the conditioning of air, including cooling, heating, dehumidifying, and ventilating; application of refrigeration in cold storage. Messrs. MACKEY and FEITNER.

3590. *GAS-TURBINE PLANTS.* Elective for graduate students and seniors in Mechanical Engineering. Second term. Two recitations a week. A fundamental study of the various cycles and apparatus involved in the modern gas-turbine plant. Performances and suitability of this type of power plant for various applications. Mr. ELLENWOOD.

INDUSTRIAL AND ENGINEERING ADMINISTRATION

3231. *PRINCIPLES OF INDUSTRIAL ACCOUNTING AND COST FINDING.* Credit three hours. A basic course in modern industrial accounting and in cost finding. Messrs. SCHULTZ and SCOTT.

3232. *PERSONNEL MANAGEMENT.* Credit three hours. This course involves an investigation and evaluation of the techniques in the handling of personnel functions. The major topics are selection and evaluation of the employee, job analysis, job rating, training, and motivation as well as the organization of the personnel department and its relationship to other departments in an industrial organization. The course is conducted with lectures, recitations, and demonstrations involving members of the class. Mr. SAMPSON.

3235. *CORPORATE AND INDUSTRIAL ORGANIZATION.* Credit three hours. An introductory course in the field of industrial management. The course starts with the industrial revolution and deals briefly with the principles of mass production, types of business enterprises, and the location and growth of industry. Then, in somewhat more detail are discussed the organization of the plant facilities and the plant personnel with special emphasis on the layout of the plant, types of organizational control, personnel functions, motion and time study, and wage payment systems. Messrs. WHITE and SAMPSON.

3241. *ELEMENTARY INDUSTRIAL STATISTICS.* Credit three hours. Required of students who elect the Industrial and Engineering Administration Option. The elementary technique of statistical analysis as applied to engineering and industrial problems. Messrs. GARRETT, LOBERG, and SCHULTZ.

3242. *STATISTICAL QUALITY CONTROL.* Credit three hours. Prerequisite, 3241 or equivalent. Study of basic statistical applications in the field of industrial

production and inspection. Various sampling, control, and inspection techniques are studied with special reference to practical applications. Underlying assumptions and limitations are discussed. Mr. SCHULTZ.

3243. *BUSINESS STATISTICS.* Credit three hours. Prerequisite, 3241. A continuation of subject matter in 3241 applicable to business problems. Given primarily for students entering the School of Business and Public Administration. Messrs. GARRETT, LOBERG, and SCHULTZ.

3247. *PRINCIPLES OF COST CONTROL.* Credit three hours. Prerequisite, course 3231 or its equivalent. This course covers in detail, through work in the laboratory, manufacturing cost systems for job orders and for continuous processes. Budgets and statements are discussed. Messrs. SCHULTZ and SCOTT.

3250. *INDUSTRIAL ACCOUNTING AND COST CONTROL.* Credit four hours. Prerequisite, 3235. A basic course in modern industrial accounting including detailed study of job order and process manufacturing cost systems. Standard costs and budgetary control are discussed. Messrs. SCHULTZ and SCOTT.

3252. *INDUSTRIAL AUDITING.* Credit two hours. Prerequisite, 3231. A study of auditing theory and practice by the use of illustrative problems pertaining to manufacturing concerns. Mr. MILLARD.

3253. *CHEMICAL ENGINEERING ECONOMICS.* Credit three hours. The course includes a basis of accounting theory and discussion of cost finding as applied to chemical plants, of the making and analysis of financial statements, and of certain problems peculiar to the chemical industry. Messrs. SCHULTZ and SCOTT.

3254. *STANDARD COSTS AND MANAGEMENT CONTROL.* Credit three hours. Prerequisite, 3250 and 3263 or 3261. Required of students who elect the Industrial and Engineering Administration Option. A detailed study of the use of standard costs and general control of production and sales through the records of costs. Profit analysis, flexible budgets, setting of material, labor, and overhead standards and the control of material, labor, and overheads are thoroughly discussed. The establishment of executive controls through cost reports and construction of such reports are also included. Messrs. SCHULTZ and SCOTT.

3255. *ELEMENTS OF INDUSTRIAL ACCOUNTING.* Credit three hours. A basic course in modern industrial accounting and cost finding.

3261. *INDUSTRIAL ENGINEERING.* Credit three hours. Prerequisites, 3235, 3250, Economics. Required of all students in Mechanical Engineering, except those who elect the Industrial and Engineering Administration Option. A study of fundamental problems in industrial management including consideration of the principles of economy involved. Study is built around a series of practical problems involving the principles and practices of: industrial organization; location and design of industrial plants; equipment selection; departmental and machine layouts; materials handling and warehousing equipment and methods; plant maintenance; time and motion study; purchasing; production control; quality control; economic lot sizes; and wage payment plans. Messrs. WHITE and MILLARD.

3262. *METHODS ENGINEERING.* Credit three hours. Prerequisite, 3235. Required of students who elect the Industrial and Engineering Administration option. A study of work simplification, the establishment of standard methods, and the setting of standard time for manufacturing and administrative operations. This covers the fundamentals of analyzing and charting operations in broad aspect, operations at a particular workplace (man-machine operation), motion study of man movements, micro-motion analysis of detailed man movements, and the time study of jobs to

determine time standards applicable for the job as performed. Laboratory periods are devoted to working practical problems in motion economy during which motion pictures are taken of operations and the films used in micro-motion analysis to arrive at improved methods. Time studies are taken in laboratory, shops, and actual factory operations from which time standards are computed. Messrs. MILLARD and WHITE.

3263. *PRODUCTION ENGINEERING.* Credit three hours. Prerequisites, 3235, 3262, 3250, Economics. Required of Mechanical Engineers who elect the Industrial and Engineering Administration option. A study of the technical and economic principles governing the manufacture of a product. Work is built around a series of practical problems dealing with production methods, selection of equipment, machine arrangement, materials handling equipment and methods, warehousing methods, departmental layout, lighting and other building services. Messrs. WHITE and MILLLARD.

3264. *PRODUCTION MANAGEMENT.* Credit three hours. Prerequisite, 3263. Required of Mechanical Engineers who elect the Industrial and Engineering Administration Option. A study of the fundamental principles and practices used in the management of a manufacturing plant including consideration of the principles of economy involved. The course covers such topics as production and materials control, purchasing, lot size, job estimating, machine capacities, equipment replacement, plant maintenance, inspection, quality control, wage payment plans, and managerial control of operations. Messrs. MILLARD and WHITE.

3265. *PRODUCTION CONTROL.* Credit three hours. Prerequisite, 3264. A detailed study of the principles and methods of production control, including: job estimating; planning, routing, scheduling, and dispatching of manufacturing operations; inspection and quality control; storekeeping; machine records and machine loading; tool crib operation; forms design; Gantt charts and the use of control boards. Messrs. WHITE and MILLARD.

3270. *INDUSTRIAL MARKETING.* Credit three hours. Prerequisites, 3235, 3250, 3241. Required of students who elect the Industrial and Engineering Administration Option. A study of industrial marketing as related to product planning, policy, and research; sales and market analysis; distribution channels; pricing and terms of sale; sales promotion; management and organization of sales force; sales control. Aspects of related purchasing problems are also covered. Mr. LOBERG.

3271. *INDUSTRIAL MARKETING RESEARCH.* Credit three hours. Prerequisite, 3270. Techniques of market research applied to specific problems related to industrial goods. Mr. LOBERG.

3272. *INDUSTRIAL SALESMANSHIP.* Credit two hours. Prerequisite, 3270. A study of basic principles of selling and the application of these principles to case problems. Mr. LOBERG.

MACHINE DESIGN

3325. *KINEMATICS, RECITATIONS.* Credit three hours. Prerequisite courses, Mechanical Drafting 3112, and Mathematics 60b. Three recitations a week throughout the term on the theory of motion; the transmission of motion; the instant-center method of determining linear and angular velocities; cams; rolling curves and friction gearing; gears and gear cutting; linkwork and miscellaneous mechanisms; belt, rope, and chain drives; and trains of mechanism. Messrs. ROGERS, BUSH, HINKLE, and NOTHMANN.

3326. *KINEMATICS, DRAWING.* Credit two hours. Must be taken with course 3325. Two drawing periods a week throughout the term devoted to drawingboard applications of the theory and principles of course 3325. Same staff as for 3325.

3327. *KINEMATICS, RECITATIONS.* Credit two hours. Prerequisite courses, Mechanical Drafting 3112, Mathematics 60b. A study of linkages; cams; spur, bevel, helical, and worm gearing; intermittent motion; trains of mechanism. Messrs. ROGERS, BUSH, HINKLE, and NOTHMANN.

3337. *MACHINE DESIGN, RECITATIONS.* Credit three hours. Prerequisite courses, 3326, 1222, 3423, and 1112. Three recitations a week throughout the term on the theoretical and practical applications of kinematics, materials, mechanics, and technology to the design of machines and machine elements with due regard to considerations as suitability of materials, safety, lubrication, construction, etc. Messrs. BLACK, HINKLE, MABIE, and NOTHMANN.

3338. *MACHINE DESIGN.* Credit two hours. Prerequisite course, 3337. Two design periods a week throughout the term. The student for the first time undertakes the design of machine parts and assemblies, and makes all the necessary calculations and drawings. Systematic calculations and such layout and detail drawings are made as are found necessary to complete each problem. Messrs. BLACK, HINKLE, and MABIE.

3351. *KINEMATICS.* Credit three hours. Two recitation, and one design-room period a week. Prerequisite courses, Descriptive Geometry 3111, Mechanical Drafting 3112, Mathematics 60b. A study of linkages; cams; spur, bevel, helical, and worm gearing; gear cutting; intermittent motion, and trains of mechanism. Messrs. ROGERS, BLACK, HINKLE, and NOTHMANN.

3352. *DYNAMICS OF MACHINERY.* Credit three hours. Two recitations and one design-room period a week. Prerequisite courses, Kinematics 3351, and Mechanics 1151. Graphical and analytical treatment of velocities, accelerations, inertia forces, static forces, and total forces; turning-effort, pin-pressure diagrams, and balancing of engines, and critical speeds. Messrs. ROGERS, BLACK, HINKLE, and NOTHMANN.

3353. *MACHINE DESIGN.* Credit three hours. Prerequisite courses, Strength of Materials 1153, Engineering Materials, Materials Processing, Dynamics of Machinery 3352. Three recitation periods a week throughout the term on the theoretical considerations and practical applications of kinematics, materials, mechanics and mechanical processes to the design of machines with due regard to selection of materials, construction, lubrication, safety, and cost. Messrs. BLACK, HINKLE, MABIE, and NOTHMANN.

3354. *MACHINE DESIGN.* Credit three hours. Prerequisite course, 3353. Two design periods and one recitation period a week throughout the term. The student undertakes to apply to practice the basic knowledge acquired in earlier courses. The course provides for the design of machine parts and assemblies involving the necessary calculations and such layout and detail drawings as are required for a complete solution. Messrs. BLACK, HINKLE, and MABIE.

3361. *ADVANCED MACHINE DESIGN.* Elective for qualified undergraduate and graduate students. Credit three hours. Three lecture-discussion periods a week. Advanced problems in analysis of machine and structural members including consideration of fatigue, creep, stress concentration, vibration, and lubrication. Special problems. Mr. BLACK.

3370. *SPECIAL INVESTIGATIONS IN MACHINE DESIGN.* Credit as arranged. Opportunity is offered to qualified students, individually or in small groups, to pursue, under direction, special investigations in machine design and related fields. Messrs. ROGERS, BLACK, and HINKLE.

MATERIALS PROCESSING

3401. *PATTERNMAKING.* Freshmen in Electrical and Mechanical Engineering. Credit one hour. First or second term. One laboratory period a week. Study of woods and other materials used in pattern construction. Analysis of various casting techniques as they affect pattern design with regard to size, quantity, and materials of article to be cast. Operation of hand and power tools used in the modern pattern shop. Messrs. CURTIS, CARPENTER, and YAWGER.

3402. *MACHINE TOOLS.* Freshmen in Electrical Engineering. Credit two hours. Second term. Two laboratory periods a week. Prerequisites, 3401; Demonstrations, discussions, and operation of the fundamental and production type machine tools and their accessories. Messrs. GEER, MACK, and MORGAN.

3403. *FUNDAMENTALS OF MACHINE TOOLS.* Freshmen in Mechanical Engineering. Credit one hour. First term. One laboratory period a week. Demonstrations and operation of the basic machine tools and their accessories. Study of structural elements as applications of mechanism. Messrs. MACK and MORGAN.

3404. *PRODUCTION MACHINE TOOLS.* Mechanical Engineers. Prerequisite: 3403. Credit two hours. Two laboratory periods a week. Demonstrations and operation studies on the use of machine tools for volume production. Tooling techniques, jigs and fixtures, and equipment arrangement. Messrs. GEER, MACK, and MORGAN.

3405. *GAGE LABORATORY.* Mechanical Engineers. Credit one hour. One laboratory period a week. Must be taken with or after 3404. A study of measuring instruments for the control of size, form, and alignment of commercial goods and tools, including gages. Standard techniques of Ordnance, Americal Standards Association, and others will be demonstrated. Practice in the use of precision equipment in calibration of measuring standards. Messrs. GEER and DISPENZA.

3407. *ADVANCED MATERIALS PROCESSING.* Work and credits as arranged with Mr. GEER.

3423. *MACHINE TOOL PROCESSES.* Sophomores in Mechanical and Electrical Engineering. Credit two hours. Either term. Two laboratory periods a week. Fundamentals of machine tools and cutting tools. Study of machine tool design as related to modern tools and methods. Demonstrations and practice of the basic operations including gear cutting methods. Operation of jigs and fixtures. Messrs. GEER, MACK, MORGAN, and others.

3424. *MEASURING INSTRUMENTS.* Sophomores in Mechanical Engineering. Credit one hour. Either term. One laboratory period a week. Must be taken with or after 3423. Study of types of gages and measuring instruments and their applications; jigs, fixtures, and demonstrations of their use. Laboratory practice in handling precision gages and comparators. Messrs. GEER and DISPENZA.

MECHANICS OF ENGINEERING

1111. *THEORETICAL AND APPLIED MECHANICS.* Credit five hours. Five recitations a week. Prerequisites, Mathematics 60a and 60b. Principles of Statics; forces and couples in a plane and in space; applications to structures and mechanisms. Principles of Dynamics; analysis of translational and rotational motion of particles and rigid bodies; velocity, acceleration, momentum, impulse, work and energy, with engineering applications. Messrs. CORNELL, PERKINS, LANG, MANSKY, LANSING, ECKMAN, and UNDERWOOD.

1112. *STRENGTH OF MATERIALS.* Credit three hours. Prerequisite, course 1111.

Stress, strain; strength and elastic properties of materials in tension, compression, and shearing; riveted joints; torsion of shafts; helical springs; shear, moment, safe loading, and deflection of simple beams; special beams; eccentric loads; columns; impact loads. Messrs. CORNELL, PERKINS, MANSKY, LANG, LANSING, ECKMAN, and UNDERWOOD.

1113. *STRENGTH OF MATERIALS.* Credit two hours. A continuation of course 1112. Continuous beams; combined stresses; principal stresses; Mohr's circle of stress; theories of failure; thick-walled cylinders; curved bars; unsymmetrical bending. Messrs. PERKINS, LANG, and MANSKY.

1114. *APPLIED MATHEMATICS.* Credit three hours. Prerequisite, course 1111. Three recitations a week. Manipulation of data and reduction to empirical equations; elementary differential equations and applications to a variety of engineering problems, including free and forced vibration of the simpler mechanisms and structures. Messrs. GOODIER, PERKINS, LANG, and MANSKY.

1121. *STATICS AND STRENGTH OF MATERIALS.* Required of students in Engineering Physics. Term 3. Three hours. Prerequisites, Mathematics 60b, Physics 16. The principles of statics applied to the calculation of forces in mechanisms and structures. Stress, strain; strength and elastic behavior in tension, compression, and shearing; torsion of shafts; springs; shearing forces, bending moments and deflections of simple beams; special beams.

1122. *STATICS AND STRENGTH OF MATERIALS.* Required of students in Engineering Physics. Term 4. Three hours. Prerequisites, 1121 and Physics 65. (A continuation of 1121.) Eccentric thrust in bars; buckling; continuous beams; combined stresses; principal stresses; theories of failure; thick-walled cylinders; curved bars; unsymmetrical bending; strain energy; Castigliano's theorem.

1125. *THEORETICAL AND APPLIED MECHANICS.* (For Chemical Engineers.) Credit three hours. Three recitations a week. Prerequisites, Mathematics 60c. Statics in a plane and in space; dynamics of particles and rigid bodies; conditions of equilibrium of force systems, application to simple structures; friction; center of gravity; velocity and acceleration; Newtonian laws of motion; moments of inertia; translation and rotation of rigid bodies. Messrs. CORNELL, LANG, and MANSKY.

1126. *MECHANICS AND STRENGTH OF MATERIALS.* (For Chemical Engineers.) Credit three hours. Three recitations a week. Prerequisite, course 1125. General plane motion of rigid bodies; work and energy, linear and angular impulse and momentum, for particles and rigid bodies; mechanical vibration of simple systems; simple gyroscopic problems.

Analysis of stress and strain; riveted and welded joints; bending of beams; statically indeterminate beams; beams of variable cross-section; beams of two materials, including reinforced concrete. Messrs. CORNELL, LANG, and MANSKY.

1127. *STRENGTH OF MATERIALS.* (For Chemical Engineers.) Credit three hours. Three recitations a week. Prerequisite, course 1126. Combined tension and compression; columns; torsion; strain energy and sudden loading; thin circular plates, cylindrical and spherical shells; thick-walled cylinders and spheres; stress concentration at holes, notches, and other structural discontinuities. Messrs. CORNELL, LANG, and MANSKY.

FIVE-YEAR CURRICULUM

1151. *MECHANICS.* Credit three hours. Prerequisites, Mathematics 60c, Physics 17. The principles of statics and particle dynamics and their use in the solution of engineering problems of equilibrium and motion of machines and structures. Forces and

couples in a plane and in space; friction; velocity and acceleration; particle motion under given forces. Messrs. CORNELL, PERKINS, LANG, and MANSKY.

1152. *MECHANICS AND STRENGTH OF MATERIALS.* Credit three hours. Prerequisite, course 1151. Dynamics of rigid bodies; motions of translation, rotation, and general motion, in two dimensions under given forces; impulse and momentum; work and energy. Stress and strain; tension, compression, and shear; analysis of riveted and welded joints; torsion of shafts; helical springs. Messrs. CORNELL, PERKINS, LANG, and MANSKY.

1153. *STRENGTH OF MATERIALS.* Credit three hours. Prerequisite, course 1152. Elementary theory of beams; bending moments and shear forces; deflections; combined tension or compression and bending; beams of non-uniform section; composite (including reinforced concrete) beams; buckling of compression members; elastic strain energy; stress due to sudden loading; beams on several supports; strain energy methods for the calculation of elastic deformations. Messrs. CORNELL, PERKINS, LANG, and MANSKY.

1154. *ADVANCED MECHANICS AND STRENGTH OF MATERIALS.* Credit three hours. Prerequisite, course 1153. General bending and twisting; bending of thick curved bars, principal stresses in two and three dimensions; theories of failure; stress in thick-walled cylinders.

Dynamics of jets, rockets, gyroscopes, and governors. Elements of dynamics in three dimensions. Messrs. CORNELL, PERKINS, LANG, and MANSKY.

1155. *APPLIED MATHEMATICS.* Credit three hours. Prerequisite, course 1111. The derivation and solution of ordinary differential equations arising in engineering problems of fluid flow, heat conduction, control mechanisms, jet propulsion, vibration in one degree of freedom. Messrs. PERKINS, LANG, and MANSKY.

1161. *ADVANCED ENGINEERING MATHEMATICS.* Elective for graduates and qualified undergraduates. Credit three hours. Prerequisite, 1114 or equivalent. An introduction to the mathematics used in the solution of advanced engineering problems. Partial differentiation; line and surface integrals, ordinary differential equations, power series solutions; Fourier series. Fourier integrals; partial differential equations. Mr. GOODIER.

1162. *MECHANICS OF VIBRATION.* Elective for graduates and qualified undergraduates. Credit three hours. The characteristic phenomena of mechanical vibrations encountered in engineering, and their quantitative investigation, illustrated by a group of typical vibrating systems. Representation of simple harmonic motion; combination of several simultaneous motions; simple cases of free and forced vibrations, with damping; resonance; principles of transmission and isolation of vibration; systems of variable mass and variable elasticity; systems with several degrees of freedom; vibrations of taut wires, bars, beams, rings, membranes, and plates; relation of vibration and noise; self-excited vibration; detection and measuring instruments; examples of diagnosis and preventive measures. Mr. GOODIER.

1163, 1164. *APPLIED ELASTICITY.* Elective for graduates and qualified undergraduates. Continuing two terms. Credit three hours each term. General theorems of the elastic solid, reciprocal theorem, sudden loading; tension, flexure, and torsion of bars of arbitrary section; Castigliano's theorem with application to frames, rings loaded in and normal to plane, spiral and helical springs; stress in thick cylinders and discs due to pressure, heating, and rotation; beams on elastic foundations; symmetrical deformation of thin tubes; propagation of stress waves in bars; thermal stress; stress-analysis and deflection of plates and shells; vibration of beams. Mr. GOODIER.

1165. *THEORY OF ELASTIC STABILITY.* Elective for graduates and qualified undergraduates. Credit three hours. Mathematical analysis of the conditions under which columns, beams, rings, tubes, thin plates, and thin curved shells may fail by general or local buckling. Applications to mechanical, civil, naval, and aeronautical structures. Mr. GOODIER.

1166. *PHOTOELASTICITY.* Elective for graduates and qualified undergraduates. Credit two hours. One lecture and one laboratory-lecture period each week. Optics of photoelasticity; plane and circularly polarized light, monochromatic and white light, fringes, isochromatics and isoclinics; discussion of models, materials, and preparation. Elements of elasticity, including equilibrium and compatibility equations for plane stress, and stress functions; methods for determining principal stresses from photoelastic observations. In the laboratory, experiments on the calibration of color and fringe scales by tension, compression, and bending, are followed by tests on centrally loaded beams, the determination of stress concentration factors, and the separation of principal stresses. Mr. CUYKENDALL.

1167. *MECHANICS OF JET PROPULSION.* Elective for graduates and qualified undergraduates. Credit two hours. Principles of linear and angular momentum; application to rockets and jet motors; subsonic and supersonic flow through nozzles; shock waves; dynamic similarity. Mr. GOODIER.

1180. *SEMINAR IN APPLIED MECHANICS.* Elective for graduates (undergraduates by special permission). Each term. Credit, one hour each term. One discussion period each week. Current research papers in applied mechanics reported and discussed by members of the group. Mr. GOODIER.

ENGINEERING MATERIALS

1221. *ENGINEERING MATERIALS.* Credit three hours. Prerequisite, 5761, 5762. An elementary lecture course in Engineering Materials covering the metallurgy of iron and steel, the constitution of metals and alloys, the metallography of iron and steels, alloy steels, non-ferrous metals and alloys. Messrs. JEFFREY, OTTO, and YOUNG.

1222. *ENGINEERING MATERIALS.* Credit three hours. Prerequisite, 1221. An elementary lecture course in Engineering Materials covering corrosion, fuels and their combustion, refractories, cementing materials and concrete, wood, rubber, plastics, lubricants, and the testing and inspection of materials. Messrs. JEFFREY, OTTO, and YOUNG.

1223. *ENGINEERING MATERIALS.* Required for Electrical Engineers. Term 5. Credit three hours. Two lectures and one laboratory period each week. Prerequisites, 5761, 5762.

A study of the properties of ferrous and non-ferrous metals and alloys, and non-metallic materials such as cementing materials and concrete, plastics, wood, rubber, thermal and electrical insulating materials. Special attention will be given to electrical and magnetic properties.

The laboratory will illustrate materials testing, including mechanical and electrical properties of these materials. Messrs. JEFFREY and MOYNIHAN.

1231. *ENGINEERING MATERIALS LABORATORY—METALS AND ALLOYS.* Credit three hours. Prerequisites, 1221, 1222, 1112, but may be taken simultaneously with the latter course. A laboratory course dealing with materials testing and the properties of metals and alloys. The following types of tests with testing machines and strain measurement will be performed: tension, torsion, compression, bending,

impact, fatigue, hardness, ductility, and calibration. The relation between the properties, structure, selection, inspection and use of metals and alloys will be shown by the following experiments: carbon steels, cast irons, heat treatment, non-ferrous metals and alloys, metallography, spectrography, radiography, and magnaflux. Messrs. MOYNIHAN, EHRHART, PURCELL, GIESELER, and PEARSON.

1232. *ENGINEERING MATERIALS LABORATORY—NON-METALLIC MATERIALS.* Credit three hours. Prerequisite, 1222 and 1231. A laboratory course dealing with materials testing and the properties, composition, selection and use of the following non-metallic materials: oils and lubricants, fuels (solid, liquid, and gaseous) and combustion, plastics, wood, cementing materials and concrete. Messrs. MOYNIHAN, EHRHART, PURCELL, and SWINGLE.

1251. *ENGINEERING MATERIALS RESEARCH.* Credit one hour for forty hours of work. Prerequisites, 1231, 1232. Open to a limited number of seniors and graduate students who have shown a proficiency in this field. Special problems and investigations are carried on under staff supervision. Messrs. JEFFREY, MOYNIHAN, EHRHART, OTTO, PURCELL, and YOUNG.

1252. *APPLIED PHYSICAL METALLURGY.* Credit three hours. Elective. Prerequisite, 1231. This course covers the applications of physical metallurgy to problems in engineering. This will include all processing operations including casting, mechanical working and heat treatment, and the subsequent inspection and use of ferrous and non-ferrous metals and alloys. The significance and control of mechanical properties will be emphasized. Mr. JEFFREY.

1253. *PHYSICS OF ENGINEERING MATERIALS.* Any term. Credit variable. Open to graduate students by permission. Mr. SACK.

This course offers opportunity for individual research in the field of physical properties of engineering and applications of physical methods to production control.

MECHANICAL ENGINEERING LABORATORY

3601. *MECHANICAL ENGINEERING LABORATORY.* Second term. Credit three hours. Regularly taken by five-year students in their eighth term. Two laboratory periods a week. Prerequisite, 3535. A laboratory study of instruments and methods used in measurement and control of variables important in mechanical and thermal processes. Measurement of pressure, temperature, speed, torque, power, flow rate, and humidity. Automatic controllers. Mr. MACKEY and others.

3602. *MECHANICAL ENGINEERING LABORATORY.* First term. Credit three hours. Regularly taken by five-year students in their ninth term. Two laboratory periods a week. Prerequisites, 3601, 3536. Laboratory instruction in the performance, testing, operation, and maintenance of internal combustion engines and engine accessories. Messrs. FAIRCHILD, L. L. OTTO, and KATZ.

3603. *MECHANICAL ENGINEERING LABORATORY.* Second term. Credit three hours. Regularly taken by five-year students in their tenth term. Two laboratory periods a week. Prerequisites, 3601, 3536. Must be preceded by or taken with 3582. Laboratory instruction in the performance, testing, operation, and maintenance of complete steam and gas power plants and plant units. Messrs. GAGE, ANDRAE, and ERDMAN.

3640. *INTRODUCTORY MECHANICAL LABORATORY.* Each term. Credit three hours. Prerequisites, 3535 and 3536, or equivalents (may be taken simultaneously with 3536). Experiments commonly taken from the following group: temperature measurement; pressure measurement and control; steam calorimetry; indicators and

planimeters; fluid flow and flow measurements; exhaust gas analysis and boiler water conditioning; dynamometers; jet pumps; steam engines. Messrs. ANDRAE, ERDMAN, and DROPKIN.

3642. *MECHANICAL LABORATORY.* Each term. Credit three hours. Laboratory instruction on steam power plants and power plant auxiliaries, internal combustion engines and accessories, hydraulic machinery, and pneumatic machinery. Messrs. GAGE and FAIRCHILD.

3651. *EXPERIMENTAL ENGINEERING.* Elective. Any term. Credit to depend upon hours of actual work. Recitation and laboratory instruction will be given to a limited number of undergraduates and graduate students interested in work to supplement that given in required courses in the fields of internal combustion engines, heat transfer, refrigeration, air conditioning, and instruments. Messrs. MACKEY, GAGE, ANDRAE, FAIRCHILD, ERDMAN, and OTTO.

3655. *GRAPHICAL COMPUTATION AND REPRESENTATION.* Elective to undergraduate students who have completed four terms or to graduate students. Each term. Credit two hours. Design of slide rules, network charts, and alignment charts; derivation of empirical equations to fit experimental data. Mr. MACKEY.

ELECTRICAL ENGINEERING

COURSES BY GROUPS. . . Within the School of Electrical Engineering the courses are numbered in groups with each course designated by a four-digit number. In general, the fourth digits from 1 to 5 denote theory courses and those from 6 to 9 denote laboratory courses.

The Index of course descriptions follows:

GENERAL COURSES

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MACHINERY THEORY AND LABORATORY COURSES

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4321 Electrical Machine Theory (p. 111)
4326 Power Laboratory (p. 111)
4331 Electrical Design Economics (p. 111)
4334 Economics of Public Utilities (p. 111)
4341 Motor Control (p. 112)
4342 Application of Motors (p. 112)
4343 Aircraft and Marine Electric Power Control Systems (p. 112)
4351 Low Frequency Heating and Industrial Distribution (p. 112)
4361 Power Systems (p. 112)
4362 Transmission of Electrical Energy (p. 113)
4363 Stability of Electric Power Systems (p. 113)
4364 Protection and Relaying on Power Systems (p. 113)
4365 Symmetrical Components (p. 113)
4371 High Voltage Phenomena (p. 113)
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4392 Project (p. 113)

COURSES IN INDUSTRIAL ELECTRONICS

4411 Electronic Control Equipment (p. 114)
*4415 Advanced Electronic Controls (p. 114)
4421 Electronic Power Converters (p. 114)
*4422 Electronic Inverters (p. 114)
*4451 High Frequency Heating (p. 114)
4491 Project (p. 115)
4492 Project (p. 115)

*One of these to be chosen as Option Elective in Industrial Electronics Option.

COURSES IN RADIO AND COMMUNICATIONS

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4512 Radio and Communication Theory (p. 115)
4513 Communication Networks (p. 115)
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4517 Radio and Communication Laboratory (p. 116)
*4521 Radio Broadcasting (p. 116)
*4522 Telephone and Telegraph Systems(p. 116)
*4526 Design and Construction of Vacuum Tubes (p. 116)
*4531 Television Systems (p. 117)
*4541 Applied Acoustics (p. 117)
*4551 Radio Aids to Navigation (p. 117)
4561 Ultra High Frequency Systems (p. 117)
4565 Electro Magnetic Waves and Radiation (p. 117)
4591 Project (p. 118)
4592 Project (p. 118)

At least 3 hours to be chosen from these for Option Elective in Radio and Communication Option.

COURSES IN ILLUMINATION

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COURSES FOR CIVIL, MECHANICAL, AND CHEMICAL ENGINEERS

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4934 Electrical Engineering (for Mechanical Engineers) (p. 119)
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4951 Electrical Engineering (for Chemical Engineers) (p. 120)
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4953 Electrical Engineering (for Chemical Engineers)
4954 Electrical Engineering (for Chemical Engineers)

GENERAL COURSES

4021. *COMPOSITION OF TECHNICAL REPORTS.* Term 9. Required. Credit three hours. One lecture and one recitation each week. Texts: *Writing the Technical Report,* NELSON; *Report Writing,* GAUM and GRAVES.

The objective of this course is to develop the basic principles of exposition, the knowledge of suitable form, and the appreciation of function that will enable students to design and construct technical reports which meet professional standards.

4031. *ENGINEERING MATHEMATICS.* Term 4. Required. Credit three hours. Three recitations each week. Prerequisite, Mathematics 60c. Text: *Engineering Mathematics,* SOHON.

The purpose of this course is to develop an understanding of certain mathematical concepts and processes which are of wide utility in the solution of engineering problems. The topics include determinants, complex numbers, hyperbolic functions, Fourier series, methods of interpolation, theory of equations, probability and least squares, vector algebra, vector calculus, and dimensional analysis.

4035, 4036. *OPERATIONAL ANALYSIS.* Terms 9 and 10. Elective. Credit three hours each term. Two recitations and one computing period each week. Prerequisite, 4311.

Among the topics of the course are: functions of real and of complex variables; infinite series; integral equations; Laplace and Fourier transforms; generalized expansion theorems for differential equations and difference equations. The course concludes with analyses of ladder networks and of transients in circuits with lumped and with distributed parameters.

4041. *NON-RESIDENT LECTURES.* Term 10. Required. Credit one hour. One lecture each week.

Representatives of industry are invited to deliver a series of lectures intended to assist students in their selection of employment and to aid in the transition from college to industrial life. Certain lectures given under the auspices of the Ithaca Section of AIEE may be specified for required attendance.

4051. *PATENTS.* Elective. Credit one hour. One lecture-recitation a week. Text: *mimeographed notes.* Open to Seniors in Electrical or Mechanical Engineering and to others by special permission.

Patent laws of the United States are studied, including the procedure in obtaining a patent. Typical patents are discussed. Additional topics include: interference actions; actions coming before the Federal courts; the engineer as an expert witness; and the rights of inventors.

COURSES IN BASIC ELECTRICAL ENGINEERING

4111. *BASIC ELECTRICAL ENGINEERING.* Term 4. Required. Credit four hours. One lecture, two recitations, and one computing period each week. Prerequisites, Math 60c; Physics 17; Chemistry 102 or 104. Text: *Electrical Engineering,* STRONG.

This is the first of two successive courses presenting the basic elements of electrical engineering which are common to the several branches of study which follow. They present the elemental concepts and laws of electricity and their application with emphasis on analysis rather than the memorization of formulas. The student is encouraged to regard the physical significance of problems and to question the mathematical result of a combination of formulated principles.

The material covered in the first course is identified with the following topics: conductors and resistance; electrical measuring instruments; resistance measurement;

electromotive force and its sources; electromagnetic induction; alternating emf; power-distribution circuits; d-c electrical networks and methods of solution; conductors of non-uniform section or material; mapping of current paths; magnetics, magnetic circuits and forces; electromagnets; self and mutual inductance, coupling, reactors; electrostatic energy, fields, and forces; capacitance; transient and alternating currents in circuits with resistance and inductance, in circuits with resistance and capacitance, and in series circuits with resistance, inductance, and capacitance.

4112. *ALTERNATING-CURRENT CIRCUITS.* Term 5. Required. Credit four hours. Three recitations and one computing period each week. Prerequisites, 4111, and 4031. Text: *Alternating-Current Circuits,* KERCHNER and CORCORAN.

The study of alternating-current circuits is made under the following topics: average and effective values; vectors and vector algebra; power and power factor; series circuits; series resonance, and loci; parallel circuits; series-parallel circuits, and loci; a-c networks, and theorems for solution; equivalent circuits; coupled circuits; air-core and iron-core transformers; transmission lines; power factor correction; three-phase circuits; balanced three-phase relations; three-phase power; measurement of three-phase power and energy; three-phase transmission; determination of phase sequence; non-sine waves in single phase and in polyphase circuits; harmonics in three-phase circuits; introduction to filters.

4116. *ELECTRIC-CIRCUIT LABORATORY.* Term 5. Required. Credit three hours. One lecture and one lecture-laboratory period each week. Prerequisite, 4111. Must be accompanied or preceded by 4112. Text: *Mimeographed Notes,* supplemented by reference to *Electrical Measurements, LAWS,* and to *Electrical Engineering,* STRONG.

This course and the two machinery laboratory courses which follow it require a preparatory study of references, a laboratory experiment, a written report consisting primarily of solutions of problems based on laboratory and other data, and a group discussion of the reports. The principal topics studied are: basic direct-current circuits, with constant and with varying resistors; application and analysis of circuits in bridge and in other measuring apparatus; thermocouple circuits; temperature measurement and the basic steady-state heat-flow conditions in electrical machines; construction, characteristics, and circuit connections of permanent-magnet moving-coil instruments and of the wattmeter; equipment, procedure, and circuits used in calibrating, checking, and standardizing electrical instruments and secondary standards; the construction, characteristics and circuit connections of copper-oxide rectifiers and of instruments for measuring alternating voltage and alternating current; characteristics of ideal and of practical resistors, inductors, and capacitors; characteristics of single-phase circuits under approximately sinusoidal conditions of waveform, at power frequencies; characteristics of thermal circuits under elementary transient conditions.

4121. *ELECTRON TUBES AND CIRCUITS.* Term 6. Required. Credit three hours. Three lecture-recitations each week. Prerequisite: 4112. Must be preceded or accompanied by course 4126. Text: *Applied Electronics,* M.I.T. staff; and supplementary notes. This is the first of a group of courses which present and expand the fundamental laws of electronic behavior and correlate such behavior with the functioning of simple electronic circuits.

The material covered in this first course includes: the theory of matter and of electron emission; emitters; conduction in high vacuum and in gas; diode characteristics; photoelectric cells; the construction, characteristics, and control of the cathode ray tube; rectification and filtering with L and π filters; high vacuum triode characteristics, tube parameters, and equivalent circuit studies; multi-grid tube characteristics; and R-C coupled amplifier characteristics.

4122. *ELECTRONIC CIRCUIT ELEMENTS.* Term 7. Required. Credit four hours. Two lectures, one lecture-laboratory, and one computing period each week. Prerequisites, 4121 and 4126. Text: *Applied Electronics,* M.I.T. staff; and supplementary notes.

This course continues the study of electron tubes and circuits begun in courses 4122 and 4126. It deals with: amplifiers including transformer coupling; power amplifiers; push-pull operation of class A, B, and C amplifiers; analysis of single tube oscillators with effects of feed-back; theory of amplitude and of angular modulation and detection with simple circuits; thermionic gas-filled triodes with methods of control and with application to full-wave rectifiers and motor control; and inverter circuits with analysis of their operation.

4124. *ELECTRONIC TUBES.* Term 5. Required. Credit three hours. Two lecture-recitations and one lecture-laboratory period each week. Prerequisite, 4111. Text: *Applied Electronics,* M.I.T. staff; and supplementary notes.

This course is an abridgement of courses 4121 and 4126 with emphasis on the characteristics of diodes, triodes, and multigrid tubes, of both the high-vacuum and gas-filled types and their application in simple electronic circuits. Course 4124 will not be given after the fall term 1946–1947.

4125. *ELECTRONIC CIRCUITS.* Term 6. Required. Credit three hours. Two lecture-recitations and one lecture-laboratory each week. Prerequisite course, 4124. Text: *Applied Electronics,* M.I.T. staff; and supplementary notes.

This course is an abridgement of course 4122, with emphasis on circuit characteristics. Analytical studies of the circuits are included. Course 4125 will not be given after the spring term 1946–1947.

4126. *ELECTRONICS LABORATORY.* Term 6. Required. Credit two hours. One lecture-laboratory and one computing period each week. Prerequisite, 4112. Must be preceded or accompanied by course 4121. Text: *Applied Electronics,* M.I.T. Staff; and supplementary notes.

This course is a laboratory study of topics selected from the accompanying theory course. The characteristics of typical electron tubes are determined and these tubes are then utilized in appropriate circuits for more complete tests and analyses.

4128. *ELECTRONIC-EQUIPMENT SHOP.* Term 6. Required. Credit one hour. One lecture-laboratory period each week. Prerequisite, 4112. Must be preceded or accompanied by 4121 and 4126.

Simple electronic circuits are studied to develop an intelligent use of a variety of measuring instruments, and to promote a general familiarity with the form and proper use of circuit components and their combinations. Good construction is specifically noted; resistor and condenser sizes and color codes are observed; faulty parts are recognized and replaced. Skill in handling tools is developed, and the use of approved methods of construction is encouraged. Although generally simple circuits such as amplifiers and power supplies are studied, a moderately skilled student may construct, repair, or redesign a more complicated unit such as a small radio receiver or transmitter, an electronic instrument, or an experimental circuit in which he is interested.

4131. *BASIC COMMUNICATION SYSTEMS.* Term 7. Required. Credit two hours. One lecture and one lecture-laboratory period each week. Prerequisites, 4121 and 4126. Must be preceded or accompanied by 4122.

The elements of wire and radio telephone and telegraph systems are studied. Attention is given to microphones, antennas, loud speakers, manual and automatic telephone exchanges, repeaters, multiplex circuits, teletype and picture transmitters, and radio transmitters and receivers. Inspection trips are included in the course.

COURSES IN MACHINERY

4211. *DIRECT-CURRENT MACHINERY.* Term 5. Required. Credit three hours. One lecture, one recitation, and one computing period each week. Prerequisite, 4111. Text: *Direct-Current Machinery,* KLOEFFLER, BRENNEMAN, and KERCHNER.

A study is made of the construction, operating characteristics, applications, and control of direct-current generators, motors, and motor-generator sets.

Among the topics studied are: generator and motor parts and construction; armature windings; operating characteristics; armature reaction; commutation, and brush setting; losses and efficiency; rating; parallel operation of generators; motor applications; manual and automatic motor controllers; special generators such as boosters, welders, Amplidyne, Rototrol, aircraft, and marine types, and dynamotors; generators and motors for bus, train, and marine service; storage-battery charging equipment and circuits.

4216. *ELECTRICAL MACHINERY LABORATORY.* Term 6. Required. Credit four hours. One lecture, one recitation, and one lecture-laboratory period each week. Prerequisites, 4116 and 4211. Must be accompanied or preceded by 4221. Text: mimeographed notes.

Following a study of direct-current magnetization in general and the magnetic circuits of dynamos, the course proceeds to measured and predicted characteristics of direct-current generators and motors with all common methods of excitation; characteristics of generators in parallel; detection and correction of faulty commutation; construction, connection, and operating characteristics of typical direct-current motor-controllers; measurement of segregated losses, and prediction of efficiency of dynamos by mechanical-drive and by retardation methods; characteristics and typical applications of the Amplidyne.

4221. *ALTERNATING-CURRENT MACHINERY.* Term 6. Required. Credit three hours. Two recitations and one computing period each week. Prerequisite, 4112. Text: *Principles of Alternating Current Machinery,* BRYANT and JOHNSON.

A study is made of the construction, operating characteristics, applications, and control of transformers, synchronous machines, and single-phase and polyphase induction motors.

Among the topics studied are: equivalent-circuit diagrams; regulation; losses and efficiency; single-phase and polyphase connection of transformers; parallel operation of synchronous generators; circle diagrams of polyphase induction motors. Vector diagrams and graphical methods are used extensively.

4226. *ELECTRICAL-MACHINERY LABORATORY.* Term 7. Required. Credit four hours. One lecture, one recitation, and one lecture-laboratory period each week. Prerequisites, 4116, 4211, and 4221. Text: mimeographed notes.

The course begins with a general study of basic principles of alternating-current magnetization, and circuit relations involving non-sinusoidal current and voltage, including detailed analysis of balanced and of unbalanced polyphase circuits in which harmonics arise in the load or in the generator. Application of these principles is then made in analyzing selected operating characteristics of single-phase constant-potential transformers, single-phase and three-phase induction motors, and synchronous motors and generators, including parallel operation of the latter. There is a brief study of the construction, connections, and characteristics of typical meters used in the measurement of electric energy and demand.

COURSES IN POWER

4311. *ADVANCED CIRCUIT ANALYSIS.* Term 8. Required in the following options: Power Generation and Distribution, Power Utilization, Industrial Electronics, and Illumination. Credit three hours. Two lectures and one computing period each week. Prerequisites, 4221 and Math 200.

This course treats of typical circuits by which electric energy is transmitted. The physical meaning of the parameters which are used in describing transmission circuits is considered. A review of single-energy transients precedes a detailed analysis of double-energy transients. Ladder networks are viewed as approximate equivalents of circuits having distributed parameters. The behavior of polyphase circuits on which there are faults or unbalanced loads is analyzed by the method of symmetrical components.

4321. *ELECTRICAL MACHINE THEORY.* Term 8. Required in the following options: Power Generation and Distribution, Power Utilization, Industrial Electronics, and Illumination. Credit two hours. Two recitations each week. Prerequisite, 4221. Text: *Alternating-Current Machinery,* LAWRENCE; supplementary notes.

This course extends the analysis of certain subjects of the prerequisite course. Among its topics are: analysis of magnetomotive force and of air-gap flux in synchronous and in induction machines for harmonics in time and in space; effects of such harmonics on induced voltage and on torque; two-reaction analysis of salient-pole synchronous machines; analyses of single-phase induction motors and commutator alternating-current motors.

4326. *POWER LABORATORY.* Term 9. Required in the following options: Power Generation and Distribution, Power Utilization, Industrial Electronics, and Illumination. Credit two hours. One lecture and lecture-laboratory period each week. Prerequisites, 4226 and 4311. Text: mimeographed notes.

This course continues the study of basic principles of alternating-current magnetization, and the exemplification of these principles under the favorable conditions provided by selected transformers. Salient-pole synchronous-machine principles are examined from the standpoint of the two-reaction theory. The reactances are measured by several methods and the theory is applied to the analysis of torque-angle relations, steady-state stability, and the voltage regulation of generators. The measurement and the significance of the transient reactances are briefly studied. The special combinations of conditions that arise in commutating alternating-current motors are analyzed for a selected machine. The course includes circuit studies applied to selected alternating-current bridges and to symmetrical-component analysis of faults on transmission lines.

4331. *ELECTRICAL DESIGN ECONOMICS.* Term 9. Required in Power Generation and Power Utilization Options. Credit three hours. Two recitations and one computing period each week. Prerequisites, 4211 and 4221. Text: *Elements of Electrical Design,* STILL; mimeographed notes.

The object of the course is to acquaint the student with technical and economic problems encountered in the design of resistors, electro-magnets, cables, condensers and condenser bushings, transformers, and rotating electrical machines.

4334. *ECONOMICS OF PUBLIC UTILITIES.* Elective. Credit two hours. Two recitations each week. Prerequisite, Economics 3. Text: *Elements of Utility Rate Determination,* BRYANT and HERRMANN.

The course is a study of the following topics: the development of public utilities and governmental regulatory bodies; principles of capitalization and depreciation of utility property; the capital structure of power companies; analysis of costs, and

principles of rate-making; long-term trends of size of plant, efficiency, costs, and rates; the relation of the industry to other segments of the economic system.

4341. *MOTOR CONTROL.* Term 9. Required in the following options: Power Generation and Distribution, Power Utilization, Industrial Electronics, and Illumination. Credit two hours. One lecture and one recitation each week. Prerequisites, 4211, 4221, 4216, and 4226. Text: *Controllers for Electric Motors,* JAMES and MARKLE.

The course is a study of the design and the functioning of typical controllers and protective devices for direct-current and for alternating-current motors. Among the topics are: problems of manual and automatic acceleration, dynamic braking, power regeneration, plugging, and voltage control for direct-current motors, design of resistors and magnetic contactors; interpretation of controller diagrams.

4342. *APPLICATION OF MOTORS.* Term 10. Required in Power Utilization Option. Credit three hours. One lecture, one recitation, and one computing period each week. Prerequisites, 4341 and 4326. Text: *Electric Motors in Industry,* SHOULTS, RIFE, and JOHNSON.

Characteristics of motors and requirements of typical loads are analyzed and correlated so that the motor selected for the load is of the proper type and rating. The course includes a study of motor duty cycles, adjustable-speed alternating-current drives, coordinated-drive systems, and "synchro" systems.

Inspection trips may replace several of the computing periods.

4343. *AIRCRAFT AND MARINE ELECTRIC POWER AND CONTROL SYSTEMS.* Term 10. Elective. Credit two hours. Two recitations each week. Prerequisites, 4321 and 4341. Text: mimeographed notes.

Modern developments in aircraft electric systems are studied, with attention given to meeting the special requirements imposed by rapid and extreme changes in temperature, pressure, and humidity. Selected topics include: relative advantages of alternating-current and direct-current systems; selection of voltage and of frequency; methods of driving generators; reliability of operation; saving of weight.

After outlining the problems and principles of ship propulsion, a study is made of the relative advantages of available main drives, the design of power-distribution systems, and the selection of motors and control equipment.

4351. *LOW-FREQUENCY HEATING AND INDUSTRIAL DISTRIBUTION SYSTEMS.* Term 8. Required in Power Utilization Option. Credit three hours. Two lectures and one computing period each week. Must be preceded or accompanied by 4311. Text: *Industrial Electric Heating,* STANSEL.

The first part of this course deals with the construction, characteristics, and application of all varieties of electric heating apparatus commonly employed in industry except those based on high-frequency dielectric heating. Principal emphasis is given to arc furnaces and to low-frequency induction furnaces.

The remainder of the course is devoted to current practice and to the apparatus employed in the design of electric-power distribution systems in industrial plants.

4361. *POWER SYSTEMS.* Term 8. Required in Power Generation and Distribution Option. Credit three hours. Two recitations and one computing period each week. Prerequisite, 4221. Text: *Electric Power Equipment,* TARBOUX.

The function and the form of the electrical apparatus included in modern power systems are studied. Among the power-system components considered are generators, switchgear, protective devices, power transformers, converters, transmission-line towers and conductors, and voltage-regulating devices.

Inspection trips to nearby power stations are planned to supplement class-room discussions.

4362. *TRANSMISSION OF ELECTRIC ENERGY.* Term 9. Required in Power Generation and Distribution Option. Credit three hours. Two recitations and one computing period each week. Prerequisite, 4311 and 4361. Text: *Introduction to Electric Power Systems,* TARBOUX.

The performance of transmission lines is analyzed through the following sequence of topics: evaluation of transmission-line parameters from the physical dimensions of the circuit; expressions for voltage and for current at sending and at receiving ends; classification of lines as short, moderately long, and long; equivalent π and T networks; development of circle diagrams to facilitate calculations of performance.

4363. *STABILITY OF ELECTRIC POWER SYSTEMS.* Term 10. Elective. Credit two hours. Two lectures each week. Must be preceded or accompanied by 4371. Texts: *Introduction to Electric Power Systems,* TARBOUX, and *Power System Stability,* CRARY.

The conditions of stability of synchronous machines and of electric power systems under both steady and transient loads are investigated by mathematical analysis.

4364. *PROTECTION AND RELAYING ON POWER CIRCUITS.* Term 10. Elective. Credit two hours. Two lectures each week. Must be preceded or accompanied by 4371. Text: mimeographed notes supplemented by manufacturer's bulletins.

The principles of the operation of typical relays and of the application of relaying systems are considered. The course includes a study of telemetering and supervisory-control equipment.

4365. *SYMMETRICAL COMPONENTS.* Term 10. Elective. Credit three hours. Three lectures and three recitation periods each week. Prerequisites, 4311, 4321, and 4361. Text: *Applications of the Method of Symmetrical Components,* LYON.

Review of the fundamental concept followed by its application to three, four, and two phase systems. Application to transmission lines, with a study of line impedance, mutual impedance and capacitance. Application to two and three winding transformers. The three phase and single phase induction motor and other unsymmetrical motor windings. The synchonous machine and power networks.

4371. *HIGH-VOLTAGE PHENOMENA.* Term 10. Required in Power Generation and Distribution Option. Credit three hours. Two lectures and one lecture-laboratory period each week. Prerequisite, 4362. Text: mimeographed notes.

The course is a study of the problems encountered in the normal operation of electric-power systems at very high voltages, of the abnormal conditions imposed by lightning, of the methods employed to assure proper operation of power systems and apparatus under high-voltage conditions, and of the devices available for laboratory testing of equipment under actual or simulated conditions.

A considerable portion of the laboratory work is done in the High Voltage Research Laboratory, located in East Ithaca.

4391 and 4392. *PROJECT.* Terms 9 and 10. Required in Power Utilization and in Power Generation Distribution options. Credit two hours for the first term and four hours for the second term.

To develop self reliance and initiative in working with engineering problems, each student, in his final terms, studies a special problem which is normally closely related to his option. The choice of a problem is made by the student after consultation with members of the teaching staff. This consultation begins during the term preceding that in which actual work on the project is begun.

Project problems may include the following: analysis and study of advanced theory in one of the several branches of engineering or allied fields; analysis and testing of equipment under conditions not considered in regular courses of study; design,

construction, and testing of special apparatus in which the student is particularly interested.

Throughout the work the student is expected to conform to good engineering practice in keeping a complete notebook of day-by-day tests and investigations. At frequent intervals he is required to submit this notebook to the supervising staff member for discussion, comments, and suggestions. He is expected to submit a well-written technical paper which describes his investigation and summarizes the results.

COURSES IN INDUSTRIAL ELECTRONICS

4411. *ELECTRONIC CONTROL EQUIPMENT.* Term 8. Required in Industrial Electronics Option. Credit three hours. Two lectures and one lecture-laboratory period each week. Prerequisite, 4122 and 4131. Text: mimeographed notes.

The course deals with the principles of electronic instrumentation and electronic control systems. A study is made of the methods of interpreting electronically a stimulus appearing in the form of heat, light, sound, or mechanical movement; and of typical electronic circuits through which such electrical effect causes the controlled device to make the desired response.

Among the subjects of laboratory experiments are timing circuits, welder controls, motor controls, voltage regulators, frequency-varying circuits, and frequency-discriminating circuits.

4415. *ADVANCED ELECTRONIC CONTROLS.* Term 10. Elective. Credit three hours. Two recitations and one computing period each week. Prerequisite course, Electrical Engineering 4421. Text: References and mimeographed notes.

This course is an intensive study of the theory and the operating characteristics of electronic circuits and equipment used to control and regulate welders, motors, generators, and other machines. These circuits are generalized, compared, and analyzed rigorously. Methods of precise control of time intervals, voltage, current, and frequency are included.

4421. *ELECTRONIC POWER CONVERTERS.* Term 9. Required in Industrial Electronics Option. Credit three hours. Two lectures and one lecture-laboratory period each week. Prerequisite course, 4411. Text: mimeographed notes.

This course continues the study of the characteristics and the applications of some of the electronic power-converting devices that were considered in introductory courses; such as power amplifiers, oscillators, single-phase and polyphase rectifiers, X-ray equipment, and welders. Laboratory work includes inspection and testing of typical equipment, with an analysis of performance.

4422. *ELECTRONIC INVERTERS.* Term 10. Elective. Credit three hours. Two lectures and one computing period each week. Prerequisite, 4421. Text: mimeographed notes.

After a survey of electronic inverter circuits of series and of parallel types, the course proceeds to the problems of inversion from high direct voltage to alternating voltage; combined conversion changing 60-cycle alternating voltage to alternating voltage of higher frequency; and feedback inversion. The operation of the parallel inverter is analyzed mathematically. Theoretical and laboratory studies are analyzed and coordinated to determine the effects of loads, supply voltage, and circuit components upon wave form, frequency, and output voltage.

4451. *HIGH-FREQUENCY HEATING.* Term 10. Elective. Credit three hours. Two lectures and one laboratory period each week. Prerequisite, 4421. Text: mimeographed notes.

The course develops the theory of high-frequency heating of dielectrics of high and of low power factor; and of induction heating, with some consideration of

unusual coil forms required for surface heating or other special applications. A study is made of the operation and the adjustment of oscillators of the types usual for these purposes.

4491 and 4492. *PROJECT.* Terms 9 and 10. Required in Industrial Electronics Option. Credit: Six hours total for both courses.

To develop self reliance and initiative in working with engineering problems, each student, in his final terms, studies a special problem which is normally closely related to his option. The choice of a problem is made by the student after consultation with members of the teaching staff. This consultation begins during the term preceding that in which actual work on the project is begun.

Project problems may include the following: analysis and study of advanced theory in one of the several branches of engineering or allied fields; analysis and testing of equipment under conditions not considered in regular courses of study; design, construction and testing of special apparatus in which the student is particularly interested.

Throughout the work the student is expected to conform to good engineering practice in keeping a complete notebook of day-by-day tests and investigations. At frequent intervals he is expected to submit this notebook to the supervising staff member for discussion, comments, and suggestions. He is expected to submit a well-written technical paper which describes his investigation and summarizes the results.

COURSES IN RADIO AND COMMUNICATIONS

4511. *RADIO AND COMMUNICATION THEORY.* Term 8. Required in Radio and Communications Option. Credit three hours. Two lectures and one recitation or computing period each week. Prerequisite, 4112 and 4122. Text: *Applied Electronics,* M.I.T. Staff; supplementary notes.

Intensive studies of the various components of radio receivers, broadcast studios, and broadcast transmitters constitute the course. The topics studied are: amplifiers with compensation, feed-back, and of class C; double-tuned transformer circuits; oscillators; modulation and detection; frequency modulation; microphones; and loud speakers.

4512. *RADIO AND COMMUNICATION THEORY.* Term 9. Required in Radio and Communications option. Credit three hours. Two lectures and one recitation or computing period each week. Must be preceded or accompanied by 4511. Text: *Radio Engineering Handbook,* TERMAN; *Ultra-High Frequency Technique,* BRAINARD et al; supplementary notes.

This course is a study of communication circuits with distributed constants and also a study of production and propagation of electro-magnetic radiation.

The topics included are: transmission line theory and applications; impedance matching; ultra-high-frequency generation; introduction to vector analysis and electromagnetic theory; propagation phenomena; and antenna characteristics and radiation.

4513. *COMMUNICATION NETWORKS.* Term 8. Required in Radio and Communication Option. Credit three hours. Three recitations each week. Must be preceded or accompanied by 4511. Texts: *Transmission Networks and Wave Filters,* T. E. SHEA; supplementary notes.

After a review of fundamental principles dealing with linear networks, a study is made of two-terminal networks, reciprocal structures, ideal reactance structures, and balancing networks. A generalized analysis of the four-terminal transmission network is made. There is an introductory study of filter characteristics and design, and of amplitude — and delay equalizers. The course includes: general equivalence theorems;

analogies between lumped networks and smooth lines; continuous and concentrated loading of lines; use of line segments as network elements.

4516. *RADIO AND COMMUNICATION LABORATORY.* Term 8. Required in Radio and Communication Option. Credit three hours. One recitation and one lecture-laboratory or computing period each week. Must be preceded or accompanied by 4511. Text: *Applied Electronics,* M.I.T. Staff; supplementary notes.

This course consists of a series of experiments closely paralleling the work of the accompanying course.

4517. *RADIO AND COMMUNICATION LABORATORY.* Term 9. Required in Radio and Communication Option. Credit three hours. One recitation and one lecture-laboratory or computing period each week. Must be preceded by or accompanied by 4512. Text: *Radio Engineering Handbook,* TERMAN; *Ultra-high Frequency Technology,* BRAINARD et al; supplementary notes.

This course consists of a series of experiments closely paralleling the work of the accompanying course.

4521. *RADIO BROADCASTING.* Elective. Term 9 or 10. Credit three hours. Two lectures and one lecture-laboratory or computing period each week. Prerequisite, 4511. Must be preceded or accompanied by 4512. Text: References to current manuals and literature.

The course deals with the engineering aspects of radio broadcasting, including the following topics: studio equipment, and problems of studio operation; transmitting equipment, and problems of operation; determination of coverage; station interference, allocation of channels, and use of directional radiating systems; performance tests and maintenance procedures; network interconnections; purpose and policy of governmental regulating bodies.

The alternate laboratory and computing periods offer an opportunity to gain practical knowledge through the facilities of the University broadcasting station and through inspection of other nearby stations.

4522. *TELEPHONE AND TELEGRAPH SYSTEMS.* Term 9 or 10. Elective. Credit two hours. Two recitations each week. Prerequisite, 4131. Text: *Electrical Communication,* ALBERT.

This course continues in greater detail the study begun in the prerequisite course. The methods of machine switching in telephone systems are studied. Consideration is given to the relative advantages of the several systems, and to the proper choice of system as influenced by the size of the community. Carrier telephony in both cable and open-wire circuits is given some attention.

Modern telegraphic methods, such as multiplex printing and facsimile transmission are studied.

Inspection trips to nearby telephone and telegraph exchanges will be arranged.

4526. *DESIGN AND CONSTRUCTION OF VACUUM TUBES.* Term 10. Elective. Credit three hours. Two lecture-recitations, and one laboratory period each week. Prerequisite, 4511. Text: *Fundamentals of Engineering Electronics,* DOW.

The purpose of this course is two-fold; first to acquaint the student with methods by which an electron tube may be designed and its performance predicted, and second to give a practical insight into the methods and problems of electron tube manufacture.

The conformal transformation of the electric field in certain simple tubes and its aid in the determination of tube parameters, effects of auxiliary grids, focusing structures, equivalent diode and other related topics will be considered in some detail. In connection with the consideration of gas and vapor tubes the fundamental prin-

ciples of the conduction of electricity through gases with particular stress upon their application to practical tube design and construction will be reviewed.

The laboratory exercises will be devoted to the actual construction of several forms of simple tubes of both high vacuum and vapor types, in which the student will assemble the elements, complete the necessary glass working and evacuation, and check the performance with that predicted.

4531. *TELEVISION SYSTEMS.* Term 10. Elective. Credit three hours. Two recitations and one computing period each week. Text: *Principles of Television Engineering,* FINK.

The objectives of the course are to demonstrate the application of physical principles in the field of television engineering, and to acquaint the student with modern practice in the design and operation of television studios, transmitters, and receivers.

Basic work in optics, illumination, cathode-ray tubes, vacuum-tube amplifiers, pulse shaping, modulation, and antenna characteristics, serves as a background for further study of television problems. In addition, such problems as scanning, synchronization, blanking, and shading are considered.

Computations involving the design of various units required for transmission and reception are carried out in the computing periods. An inspection of nearby television facilities serves to emphasize practical aspects.

4541. *APPLIED ACOUSTICS.* Term 9 or 10. Elective. Credit two hours. One recitation and one lecture-laboratory period each week. Text: *Applied Acoustics,* OLSEN and MASSA, and *Vibration and Sound,* MORSE.

A review of the laws of ideal gases, the thermo-dynamic properties of air, and the laws of the propagation of compressional waves precedes a study of the transmission of sound through tubes, horns, and unbounded media. The design of sound sources, microphones, loudspeakers, and disc recorders in keeping with acoustical principles is considered. The phenomena of reflection, absorption, and reverberation, and the limitations which these phenomena impose upon architectural design, are studied. There are laboratory experiments on absolute-pressure calibration and free-field directivity characteristics of microphones and loudspeakers, the measurement of reverberation time, and the measurement of reflection coefficients and absorption coefficients of typical materials for acoustic treatment.

4551. *RADIO AIDS TO NAVIGATION.* Term 8 or later. Elective. Credit two hours. Two recitations each week. Prerequisite, 4131. Text: *Principles of Aeronautical Radio Engineering,* SANDRETTO, and selected references.

Analysis of the principles of directive antennas is followed by discussion of long-wave and medium-wave direction finders and radio beacons. Atmospheric effects and limitations on the accuracy of determinations made by such equipment is considered. Attention is also given to medium-frequency pulsed transit-time systems and to high-frequency return-signal systems.

4561. *ULTRA-HIGH FREQUENCY SYSTEMS.* Term 8 or later. Elective. Credit three hours. Three recitations each week. Prerequisite, 4131. Text: Selected references.

A detailed coverage of micro-wave generators and detectors is followed by a study of the uses of micro-waves in radar systems, blind-landing systems for aircraft, point-to-point relay links, broad-band multiplex telephony, and television.

4565. *ELECTROMAGNETIC WAVES AND RADIATION.* Term 10. Elective. Credit three hours. Three lecture-recitations each week. Prerequisites, 4512, 4513. Text: *Electromagnetic Waves,* SCHELKUNOFF; Supplementary notes.

The course consists of a detailed study of Maxwell's electromagnetic theory and of modern communication developments based upon the theory. Among the topics

studied are: radiation from doublet, slot, and loop antennas; principles and performance of wave guides, electromagnetic horns, and beam concentrators; propagation of electromagnetic waves through space.

4591, 4592. *PROJECT.* Terms 9 and 10. Required in Radio and Communications option. Credit three hours each term.

To develop self reliance and initiative in working with engineering problems, each student, in his final terms, studies a special problem which is normally closely related to his option. The choice of a problem is made by the student after consultation with members of the teaching staff. This consultation begins during the term preceding that in which actual work on the project is begun.

Project problems may include the following: analysis and study of advanced theory in one of the several branches of engineering or allied fields; analysis and testing of equipment under conditions not considered in regular courses of study; design, construction and testing of special apparatus in which the student is particularly interested.

Throughout the work the student is expected to conform to good engineering practice in keeping a complete notebook of day-by-day tests and investigations. At frequent intervals he is expected to submit this notebook to the supervising staff member for discussion, comments, and suggestions. He is expected to submit a well-written technical paper which describes his investigation and summarizes the results.

COURSES IN ILLUMINATION

4611. *INTRODUCTORY ILLUMINATION.* Term 8. Required in Illumination Option. Credit four hours. Two recitations, one lecture-laboratory period, and one computing period each week. Prerequisite, Physics 18. Text: *Electrical Illumination,* KRAEHENBUEHL.

The course is intended to acquaint the student with the general nature of the field of illuminating engineering. Introductory study in several basic aspects of the subject is sufficiently pursued to provide an appreciation of the problems commonly encountered and of the methods of solution.

The following topics are considered: sources of light; visual perception and illusion; light control, both spectral and directional; the units and the measurement of the strength of light sources and of the intensity of illumination; general illumination design; perception, production, and mixing of colors; shadows, desirable and undesirable; architectural objectives.

4612. *ILLUMINATING ENGINEERING.* Term 9. Required in Illumination Option. Credit three hours. Two recitations and one lecture-laboratory period each week. Prerequisite, 4611. Text: *Scientific Basis of Illuminating Engineering,* MOON.

This course extends the study of some of the topics introduced in the prerequisite course. Study of current literature supplements the text. Computation of light-flux distribution and study of more difficult lighting problems are pursued. Emphasis is placed on industrial lighting problems more specialized than the problems of general lighting.

4615. *ILLUMINATION SEMINAR.* Term 10. Required in Illumination Option. Credit two hours. One two-hour period each week. Prerequisite, 4611. Reports on selected topics of current interest in illuminating engineering are presented and discussed.

4691, 4692. *PROJECT.* Terms 9 and 10. Required in Illumination option. Credit two hours first term and four hours second term.

To develop self reliance and initiative in working with engineering problems, each

student, in his final terms, studies a special problem which is normally closely related to his option. The choice of a problem is made by the student after consultation with members of the teaching staff. This consultation begins during the term preceding that in which actual work on the project is begun.

Project problems may include the following: analysis and study of advanced theory in one of the several branches of engineering or allied fields; analysis and testing of equipment under conditions not considered in regular courses of study; design, construction and testing of special apparatus in which the student is particularly interested.

Throughout the work the student is expected to conform to good engineering practice in keeping a complete notebook of day-by-day tests and investigations. At frequent intervals he is expected to submit this notebook to the supervising staff member for discussion, comments, and suggestions. He is expected to submit a well-written technical paper which describes his investigation and summarizes the results.

COURSES FOR CIVIL, MECHANICAL, AND CHEMICAL ENGINEERS

4920. *ELECTRICAL EQUIPMENT.* Required of seventh- or eighth-term, 4-year students, and ninth- or tenth-term, 5-year students in Civil Engineering. Credit three hours. Two lectures and one laboratory or computing period each week. Prerequisites, Physics 11 and 12 or Physics 15, 16, 17 and 18 and Mechanics.

A study of the fundamental physical principles of electrical engineering and their application in the common types of electrical equipment is made to enable the student to select the proper type of apparatus for the services met in ordinary practice.

4931, 4932, 4933, 4934. *ELECTRICAL ENGINEERING.* Required respectively, of fifth-, sixth-, seventh-, and eighth-term, 5-year students in Mechanical Engineering. Credit three hours each course. Two lecture-recitations and one laboratory or computing period a week. Prerequisites, Math. 60a, b, and c; Physics 15, 16, 17; Mechanics.

This sequence of four courses is designed to provide the student in Mechanical Engineering with the basic knowledge of electrical principles and equipment which may be most applicable in his field. The study treats of electric and magnetic circuits, electronic fundamentals, rectifiers and transformers, rotating machinery, control instruments and methods, electric heating and lighting, and the application of these to industrial machinery.

(Not available until fall semester 1948)

4935. *FUNDAMENTALS OF ELECTRICAL ENGINEERING.* Required of fifth-term, 4-year students in Mechanical Engineering. Credit three hours. Two lectures and one recitation-computing period each week. Prerequisites, Math. 60a, b, and c; Physics 11 and 12 or equivalent, and Mechanics. Text: *Electrical Engineering,* COOK.

This course presents the fundamentals of d-c electric and magnetic circuits and their application to d-c machinery and equipment.

4936. *FUNDAMENTALS OF ELECTRICAL ENGINEERING.* Required of fifth-term, 4-year students in Mechanical Engineering. Credit one hour. One laboratory period each week. Prerequisite, must be accompanied or preceded by 4935. Text: *Electrical Engineering,* COOK; *mimeographed notes.*

This course is a laboratory study of the material in 4935.

4937. *FUNDAMENTALS OF ELECTRICAL ENGINEERING.* Required of sixth-term, 4-year students in Mechanical Engineering. Credit three hours. Prerequisite, 4935. Text: *Electrical Engineering,* COOK.

This is a continuation of 4935. A-c electric and magnetic circuits are studied and applied to a-c machinery and equipment.

4938. *FUNDAMENTALS OF ELECTRICAL ENGINEERING.* Required of sixth term, 4-year students in Mechanical Engineering. Credit one hour. One laboratory period each week. Prerequisite, 4936. Must be accompanied or preceded by 4937. Text: *Electrical Engineering,* Cook; *mimeographed notes.*

This course is a laboratory study of the material in 4937.

4951. *ELECTRICAL ENGINEERING.* Required of ninth term students in Chemical Engineering. Credit four hours. Three lecture-recitations and one laboratory or computing period each week. Prerequisites, Math. 60a, 60b, 60c; Physics 15, 16, 17 or the equivalent. Text: *mimeographed notes.*

The course augments the electrical principles studied in Physics, especially in electric and magnetic circuit fundamentals, and to provide an understanding of the electrical equipment, its specification, application and performance, most likely to concern the Chemical Engineer. Beyond circuit fundamentals the course includes transformers, measuring and control instruments, motors and motor controllers.

4952. *ELECTRICAL ENGINEERING.* Required of tenth term students in Chemical Engineering. Credit four hours. Three lecture-recitations and one laboratory or computing period each week. Prerequisite, 4951. Text: *mimeographed notes.*

This is a continuation of 4951. Topics studied are illumination, electronic fundamentals, rectifiers, industrial heating, storage batteries, control methods and mechanisms. Design considerations are avoided except where, as in control equipment, the application and assembly of available commercial components constitutes a design problem involving the Chemical Engineer.

COURSES OFFERED BY OTHER DIVISIONS OF THE UNIVERSITY SUITABLE FOR ILLUMINATION OPTION

Hygiene 5. *INDUSTRIAL HYGIENE.* Credit two hours. Two recitations each week. Prerequisite courses, Hygiene 1 and 2.

The course deals with problems of factory sanitation, ventilation, and illumination, and emphasizes the relation of working conditions to the fatigue of workers, the occurrence of accidents, and the incidence of occupational diseases. Industrial legislation, preventive medicine in industry, and programs of accident prevention, are studied.

Public Speaking 45a. *DRAMATIC PRODUCTION: STAGE LIGHTING.* Term 9 or 10. Credit two hours. One laboratory period each week.

The course is a laboratory study of the problems encountered in lighting dramatic productions, and of the principles applied to the solution of such problems. (This course is suggested for its applicability to problems of show-window and display lighting.)

Psychology 11a. *PHYSIOLOGICAL PSYCHOLOGY OF VISION.* Term 9 or 10. Credit three hours. Two recitations and one laboratory period each week. Prerequisites, *Elementary Psychology and General Physics.*

The course is a study of the total process of visual perception. Among the topics are: structure and functioning of the eye; sensitiveness of the eye to light of various wave lengths; effects of spatial and temporal patterning, (contrast and adaptation); color mixture; discrimination of color and of brightness; theories of color vision; space perception; problems of visual fatigue; psychological studies of reading.

Physics 135. *OPTICS.* Elective. See page 134.

CHEMICAL ENGINEERING

CHEMISTRY

110a, b. *INTRODUCTORY INORGANIC CHEMISTRY.* Two terms. Credit three hours first term, two hours second term. Prerequisite, entrance credit in chemistry. Lectures. Professor LAUBENGAYER.

115. *INTRODUCTORY INORGANIC CHEMISTRY.* Recitations and laboratory practice. One term. Credit three hours. Must be taken with the first term of Chemistry 110. Professor LAUBENGAYER and assistants. Recitations: one hour a week, to be arranged. Laboratory: to be arranged.

203. *INTRODUCTORY QUALITATIVE ANALYSIS.* One term. Credit five hours. Prerequisite, one term of Chemistry 110 or special permission. Must be taken with the second term of Chemistry 110. Professor LONG and assistants. One lecture, one recitation, and three laboratory periods a week.

220. *INTRODUCTORY QUANTITATIVE ANALYSIS.* Repeated each term. Credit three hours. Prerequisite, Chemistry 203, or 205 and 206. Must be taken with Course 221. Professor NICHOLS and assistants. Two lectures and one recitation a week.

A study of the fundamental principles of gravimetric and volumetric analysis with practice in stoichiometry.

221. *INTRODUCTORY QUANTITATIVE ANALYSIS.* Repeated each term. Credit three hours. Prerequisite, Chemistry 203, or 205 and 206. Must be taken with Course 220. Professor NICHOLS and assistants. Three laboratory periods a week.

Laboratory practice in the preparation and standardization of various volumetric solutions and the analysis of a variety of substances by volumetric and gravimetric methods.

270. *SPECIAL METHODS OF QUANTITATIVE ANALYSIS.* Either term. Credit three hours. Prerequisite, courses Chemistry 220 and 221. Professor NICHOLS and assistants.

One lecture and two laboratory periods a week. The complete analysis of coal gas, the analysis of coal, the determination of the heating value of gaseous and solid fuels, and gas evolution methods. The application of instrumental methods to quantitative analysis including nephelometric, refractometric, colorimetric, electrolytic, polariscopic, combustion, conductometric, and potentiometric methods.

305a, b. *INTRODUCTORY ORGANIC CHEMISTRY.* Two terms. Credit three hours a term. Prerequisite, qualitative analysis. Open to those who are taking Course 220. Professor JOHNSON. Three lectures a week.

Lectures and written reviews. The more important compounds of carbon, their occurrence, methods of preparation, relations, and uses.

310a, b. *INTRODUCTORY ORGANIC CHEMISTRY.* Two terms. Credit three hours a term. Prerequisite or parallel course, Chemistry 305. Professor JOHNSON and Mr. DeTAR, and assistants. Three laboratory sections a week.

Laboratory practice and oral reviews. The student prepares a large number of typical compounds of carbon and familiarizes himself with their properties, reactions, and relations.

405a, b. *INTRODUCTORY PHYSICAL CHEMISTRY.* Two terms. Credit three hours a term. Prerequisite, Chemistry 305, Mathematics 60a, 60b, and 60c, and

Physics 15, 16, 17, and 18 (or their substantial equivalent). Professor BRIGGS and assistants. Three lectures a week.

A systematic presentation of modern physical chemistry. The topics include the properties of gases, liquids, and solids; physical and chemical equilibrium in homogeneous and heterogeneous systems; the Mass Law, theorem of Le Chatelier, and the Phase Rule; thermochemistry and elementary thermodynamics; the theory of solutions; ionic equilibria and the concept of activity; chemical kinetics and catalysis; photochemistry; written problems in physical chemistry.

410a, b. *INTRODUCTORY PHYSICAL CHEMISTRY.* Two terms. Laboratory and recitations. Credit three hours a term. Prerequisite or parallel course, Chemistry 405. Professor BRIGGS, Professor HOARD, and assistants. Two laboratory periods and one recitation a week.

Qualitative and quantitative experiments illustrating the principles of physical chemistry and practice in performing typical physico-chemical measurements. Recitations on the general principles of physical chemistry, based upon the lectures given in Course 405.

For description of other courses in Chemistry available as electives in the course in Chemical Engineering, see *Announcement of the College of Arts and Sciences.*

PHYSICS

For description of Physics courses 15, 16, 17, and 18, see page 132 of this Announcement. For advanced courses in Physics available as electives, consult the *Announcement of the College of Arts and Sciences.*

MATHEMATICS

60a, 60b, 60c. *ANALYTICAL GEOMETRY AND CALCULUS.* Credit three hours a term. Prerequisites, Solid Geometry and Trigonometry.

60d. *DIFFERENTIAL EQUATIONS.* Credit three hours a term. Prerequisite, Mathematics 60c or equivalent.

MECHANICAL ENGINEERING

Those courses required for the degree of Bachelor of Chemical Engineering that are given in the School of Mechanical Engineering are described in the section of this announcement that is devoted to a discussion of the work in Mechanical Engineering.

ELECTRICAL ENGINEERING

Courses 4951 and 4952 in Electrical Engineering are described on page 120 of this Announcement.

ENGLISH

2a, 2b. *ENGLISH LITERATURE AND COMPOSITION.* Credit three hours a term. Training in reading and writing.

HISTORY

70a, b. *HISTORY OF SCIENCE.* History of scientific and technological advances, and of the effects of these advances on economic and sociological progress. Credit three hours a term. Professor GUERLAC.

PUBLIC SPEAKING

1. *PUBLIC SPEAKING.* Either term. Credit three hours. Professors WAGNER and WICHELNS and assistants.

The fundamentals of speech; emphasis on speech preparation and on direct, communicative delivery.

CHEMICAL ENGINEERING

5103. *CHEMICAL ENGINEERING THERMODYNAMICS.* Fall term. Credit three hours. Prerequisite course, Chemistry 405b. Professor RHODES and Assistant Professor VON BERG.

Lectures. The development of the fundamental principles of thermodynamics, with special application to their applications to chemical engineering processes.

5104. *CHEMICAL ENGINEERING THERMODYNAMICS.* Spring term. Credit two hours a term. Prerequisite course, Chemical Engineering 5103. Professor RHODES and Assistant Professor VON BERG.

Lectures. Continuation of course 5103.

5203, 5204. *CHEMICAL ENGINEERING TECHNOLOGY.* Consecutive terms. Credit two hours a term. Professor MASON and Professor WINDING.

Lectures. A discussion of the important chemical engineering processes and industries. The first term is devoted to the consideration of inorganic chemical technology; in the second term, the discussion deals with the organic chemical engineering industries.

5303, 5404. *UNIT OPERATIONS OF CHEMICAL ENGINEERING.* Consecutive terms. Credit three hours a term. Prerequisite courses, Chemistry 405b and Chemical Engineering 5203 and 5204. Professor RHODES.

Lectures. A critical discussion of the unit operations of chemical engineering.

5353, 5354. *UNIT OPERATIONS LABORATORY.* Two terms. Credit three hours a term. Parallel courses, Chemical Engineering 5303, 5404. Professor RHODES and assistants. One laboratory period and two lectures a week.

5501. *CHEMICAL ENGINEERING STOICHIOMETRY.* Two hours credit. Professor RHODES, Professor WINDING, and Assistant Professor SMITH.

Lectures and recitations. Material balances and energy balances in chemical engineering; combustion reactions.

5503, 5504. *CHEMICAL ENGINEERING COMPUTATIONS.* Consecutive terms. Credit two hours a term. Prerequisite or parallel course, Chemical Engineering 5304. Professor WINDING.

Conferences and lectures. Problems in fluid flow and heat transfer, distillation, evaporation and drying, humidification and air conditioning, and filtration.

5505. *ADVANCED PROBLEMS IN HEAT TRANSFER.* Fall term. Credit three hours. Prerequisite courses 5503 and 5504, or equivalent. Professors RHODES and WINDING, Assistant Professor SMITH.

Conferences and lectures. Advanced topics in heat transfer. Heat transfer to fluids in streamline flow; heat transfer under unsteady-state conditions; heat transmission in mixed-flow heat exchangers, etc. Primarily for graduate students.

5506. *ADVANCED PROBLEMS IN DIFFUSIONAL OPERATIONS.* Spring term. Credit three hours. Prerequisite courses, 5503, 5504, or equivalent. Professors RHODES and WINDING, Associate Professor SMITH.

Conferences and lectures. Advanced topics in distillation, gas absorption, liquid-liquid extraction, and drying. Primarily for graduate students.

5603, 5604. *CHEMICAL ENGINEERING EQUIPMENT DESIGN.* Credit two hours a term. Prerequisite course, Chemical Engineering 5304. Assistant Professors SMITH and VON BERG.

Two lectures a week. Details of design and construction of chemical engineering equipment; piping, design of pressure vessels, detailed design of process equipment.

5605, 5606. *CHEMICAL PLANT DESIGN.* Two terms. Credit two hours a term. Professors RHODES and WINDING and Assistant Professors SMITH and VON BERG. Individual problems in the design of complete chemical plants, with estimation of costs of construction and operation.

5701. *PLANT INSPECTIONS.* Spring term. Credit one hour. Professors RHODES and WINDING.

A series of supervised inspection trips to manufacturing plants representing various chemical engineering industries. Each student is required to submit a critical and comprehensive report.

5711. *LIBRARY USE AND PATENTS.* Spring term. Credit one hour. Professors RHODES and MASON.

The effective use of technical literature; literature searches; abstracts and bibliographies; patent law.

5721. *CHEMISTRY OF EXPLOSIVES.* Fall term. Credit two hours. Professor RHODES. Two lectures a week. Open to officers of U. S. Navy only.

Manufacture and properties of primers, propellants, and high explosives.

5731. *INTERIOR BALLISTICS.* Fall term. Credit two hours. Professor RHODES. Two lectures a week. Open to officers of the U. S. Navy only.

5741. *PETROLEUM REFINING.* Alternate terms. Credit three hours. Prerequisite course 5304. Professor WINDING. Three lectures a week. Processes employed in petroleum refining.

5742. *SYNTHETIC RESINS AND PLASTICS.* Alternate terms. Credit three hours. Prerequisite or parallel course, Chemical Engineering 5304. Professor WINDING.

Polymerization reactions; manufacture and properties of synthetic resins, plastics, and rubbers.

5761. *ENGINEERING CHEMISTRY.* Fall term. Credit two hours. Prerequisite courses, Chemistry 102a and 102b, or 104a and 104b. Professor RHODES.

Lectures. A brief survey of the elements of organic chemistry, with special emphasis on those aspects of the subject that relate most directly to the work of the engineer.

Not open to students in Chemical Engineering.

5762. *ENGINEERING CHEMISTRY.* Spring term. Credit two hours. Prerequisite course 5761 or special permission. Professor RHODES.

Lectures. A brief survey of the elements of physical chemistry, with special emphasis on those aspects of the subject that relate most directly to the work of the engineer.

Not open to students in Chemical Engineering.

5851. *CHEMICAL MICROSCOPY.* Either term. Credit three hours. Prerequisite or parallel course, Chemistry 405 or 406 and Physics 17 or 18 or special permission. Professor MASON and assistants. Two laboratory periods.

Lectures and laboratory practice. The use of microscopes and their accessories in chemical and technical investigations. Micrometry; quantitative estimations; microscopical characteristics and physical chemistry of crystals; lens systems and photomicrography; study of industrial materials such as textile and paper fibres.

5853. *MICROSCOPICAL QUALITATIVE ANALYSIS (INORGANIC).* Either term. Credit two or more hours. Prerequisite, Chemical Engineering 5851. Professor MASON. Laboratory periods to be arranged.

Laboratory practice in the analysis of inorganic substances containing the more common elements.

5854. *MICROSCOPICAL METHODS IN ORGANIC CHEMISTRY.* Either term. Credit two or more hours. Prerequisites, Chemical Engineering 5851 and special permission. Professor MASON. Day and hour to be arranged.

Laboratory practice. General manipulative methods applicable to small amounts of material, crystallization procedures, determination of melting points and molecular weights, chemical tests and reactions for elements, radicals, and various types of organic compounds. Preparation of simple derivatives. Not given in 1947.

5859. *ADVANCED CHEMICAL MICROSCOPY.* Either term. Credit one or more hours. Prerequisite course, Chemical Engineering 5851 and special permission. Professor MASON and assistants.

Laboratory practice in special methods and special applications of chemical microscopy.

5953, 5954. *RESEARCH PROJECT.* Consecutive terms. Credit three hours a term; additional credit by special permission. Prerequisite course, Chemical Engineering 5304. Professors RHODES, MASON, WINDING, SWENSON, and Assistant Professors SMITH and VON BERG.

Research on an original problem in Chemical Engineering.

METALLURGY

6111. *METAL WORKING.* Either term. Credit one hour. Professor KYLE and Messrs. HILL and PERKINS. Primarily for freshmen in Mechanical Engineering.

One laboratory period a week. Demonstrations and discussions of rolling, forging, extrusion, drawing, and welding.

6112. *CASTING PROCESSES.* Either term. Credit one hour. Professor KYLE and Messrs. PATTERSON and JOYCE. Primarily for freshmen in Mechanical Engineering.

One laboratory period a week. Foundry practice. Survey of casting methods, including die-casting and permanent-mold casting. Study of sands and sand casting. Non-ferrous melting and casting. Production methods in foundry practice.

6113. *MATERIALS PROCESSING.* Second term. Credit three hours. Professor KYLE and assistants. Primarily for students in Mechanical Engineering.

Two lectures and one laboratory period a week. Discussion and demonstration of the applications of metallurgical principles in the casting and forming of metals.

6811. *INTRODUCTORY METALLOGRAPHY.* Credit three hours. Prerequisite courses 1255 and 1256 or 1231 and 1232 or special permission. Professor MASON and assistants.

One lecture and two laboratory periods a week. Microstructure of alloys, as related to composition, thermal history, and physical properties and explained in terms of general crystallographic phenomena. Preparation of specimens, and principles and use of metallographic microscopes.

6813, 6814. *ADVANCED METALLOGRAPHY.* Credit three or more hours. Prerequisite course 6811 and consent of the instructor. Professor MASON and assistants.

Two lectures and one or more laboratories a week. Lectures, conferences, and reports on various topics in physical metallurgy. Laboratory work, arranged in ac-

cordance with the interests of the student, covering heat treatment and structures of ferrous and non-ferrous alloys, or minor research problems.

Either course 6813 or course 6814 may be taken separately.

1255, 1256. *MATERIALS OF CHEMICAL ENGINEERING CONSTRUCTION.* Consecutive terms. Prerequisite or parallel course, Chemistry 405. Messrs. MASON and WINDING.

Lectures. Discussion of the nature, behavior, and applications of the important materials used in the construction of chemical engineering equipment. The discussion covers not only the ordinary metals and alloys but also special materials for use under conditions of service that may cause failure by corrosion, corrosion fatigue, creep, and other special causes. Consideration is also given to ceramics, plastics, and other non-metallic materials and to surface coatings.

Primarily for students in Chemical Engineering.

AERONAUTICAL ENGINEERING

UNDERGRADUATE COURSES

7001. *INTRODUCTION TO AERONAUTICAL ENGINEERING.* Credit three hours. An introductory course for students in all branches of engineering. Emphasis on airplane mechanics: aerodynamic forces, airplane performance, airplane stability and control. Prerequisite, Engineering Mechanics. Each term. Mr. OCVIRK.

GRADUATE COURSES

7101. *AIRPLANE MECHANICS I.* Credit three hours. Introduction; the nature of fluid forces; characteristics of airfoils; airplane performance. Prerequisite, Engineering Mechanics. Fall term, Mr. WILD.

7102. *AIRPLANE MECHANICS II.* Credit three hours. Airplane stability; airplane dynamics; control surfaces. Prerequisite, 7101. Spring term. Mr. WILD.

7103. *AIRCRAFT PROPELLER DESIGN.* Credit three hours. The aerodynamics of propellers: Betz-Glauert theory of lightly-loaded propellers; refined theories, theory of fans. Prerequisites, 7101. Not given in 1946–1947.

7201. *GASDYNAMICS I.* Credit three hours. Aero-thermodynamics and kinetic theory in relation to fluid dynamics. One-dimensional steady flow of a compressible fluid; addition of heat. Prerequisites, Physics, Integral Calculus. Fall term. Mr. KUO.

7202. *GASDYNAMICS II.* Credit three hours. Propagation of finite waves in compressible fluid; stationary and non-stationary shock waves. Nozzle and channel flow with shock waves. Prandtl-Meyer flow. Method of characteristics for stationary and non-stationary channel flow. Prerequisite, 7201. Spring term. Mr. KANTROWITZ.

7203. *AERODYNAMICS OF POWER PLANTS.* Credit three hours. Engine-supercharger characteristics at altitude; characteristics of turbojets, ramjets, etc.; aerodynamic problems of cooling, cowling, and combustion. Principles of aerodynamic design of compressors and turbines. Prerequisites, 7101, 7201, Physics. Spring term. Mr. WILD.

7301. *THEORETICAL AERODYNAMICS I.* Credit three hours. Introduction to theoretical hydrodynamics; the theory of ideal fluids; potential flows, conformal

transformation. Prerequisites, Advanced Engineering Mathematics, Differential Equations, Engineering Mechanics or Introduction to Theoretical Physics. Fall term. Mr. SEARS.

7302. *THEORETICAL AERODYNAMICS II.* Credit four hours. Wing theory; thin-airfoil theory, two-dimensional airfoil theory, Prandtl wing theory, lifting surfaces, general multiplane theory, non-stationary wing theory. Prerequisite, 7301. Spring term. Mr SEARS.

7303. *THEORETICAL AERODYNAMICS III.* Credit three hours. The aerodynamics of compressible fluids: equations of motion, small-perturbation theory (subsonic and supersonic), Janzen-Rayleigh theory, the hodograph methods, the limiting line, the method of characteristics, Prandtl-Meyer flow. Prerequisites, same as for 7301, plus 7201, 7202, and enrollment in 7301. Fall term. Mr. SEARS.

7304. *THEORETICAL AERODYNAMICS IV.* Credit three hours. The aerodynamics of viscous fluids, the boundary layer, heat transfer, fundamentals of boundary-layer stability; turbulence, the fundamentals of isotropic turbulence. Prerequisite, 7301. Spring term. Mr. KUO.

7401. *AIRPLANE DESIGN I.* Credit two hours. Stress analysis; the fundamentals of loads determination and distribution, load factors, design conditions; critical study of existing design requirements. Prerequisites, Enrollment in 7101 and 7403. Fall term. Messrs. WILD and OCVIRK.

7402. *AIRPLANE DESIGN II.* Credit two hours. Stress analysis (continued). Prerequisite, 7401. Spring term. Messrs. WILD and OCVIRK.

7403. *AIRPLANE DESIGN III.* Credit one hour. Orientation: the airplane and its components; the philosophy of airplane design: aircraft materials and processes. Prerequisite, Enrollment in 7401. Fall term. Mr. SEARS.

7404. *AIRPLANE DESIGN IV.* Credit one hour. Orientation (continued). Prerequisite, 7403. Spring term. Mr. SEARS.

7405. *AERO-ELASTIC PROBLEMS.* Credit three hours. Flutter, divergences, and aileron reversal; control-surface vibration at high speeds. Prerequisites, 7101, 7102, 7601, 7602. Not given in 1946–1947.

7501. *EXPERIMENTAL METHODS IN AERONAUTICS I.* Credit two hours. Instruments, wind tunnels, other experimental techniques in aerodynamics and aircraft structures. Fall term. Messrs. WILD and FRENKIEL.

7502. *EXPERIMENTAL METHODS IN AERONAUTICS II.* Credit two hours. A continuation of 7501 but devoted especially to experimetal methods of high-speed aerodynamics: schlieren and spark photography, etc.; the hot wire anemometer. Spring term. Messrs. KANTROWITZ and FRENKIEL.

7601. *MATHEMATICS IN AERONAUTICS I.* Credit three hours. An introduction to the mathematics used in the solution of advanced engineering problems. Partial differentiation; line and surface integrals, ordinary differential equations, power series solutions; Fourier series. Fourier integrals; partial differential equations. Not given in 1946–1947: Substitute C.E. 224b or Phys. 405.

7602. *MATHEMATICS IN AERONAUTICS II.* Credit three hours. Potential and related functions; complex variable; conformal transformation, curvilinear co-ordinates; methods of the calculus of variations. Prerequisite, 7601. Not given in 1946–1947; Substitute Math. 201 or Phys. 405.

7801. *RESEARCH IN AERONAUTICAL ENGINEERING.* (Credit to be arranged.) Independent research in a field of aeronautical science. Such research must be under

the guidance of a member of the staff, and must be of a scientific character. Prerequisites, admission to the Graduate School of Aeronautical Engineering and approval of the Director.

7901. *AERONAUTICAL ENGINEERING SEMINAR.* Credit one hour. Lectures by staff members, graduate students, personnel of Cornell Aeronautical Laboratory and visiting scientists on topics of interest in aeronautical science, especially in connection with new research. Prerequisite, admission to the Graduate School of Aeronautical Engineering.

7902. *ADVANCED SEMINAR IN AERONAUTICS.* Credit two hours. Same as 7901, but devoted to topics of advanced scientific interest. Prerequisites, 7301 or Applied Elasticity, or approval of the Director.

GENERAL COURSES OF INSTRUCTION

Described in this section are certain University courses that fall outside the jurisdiction of any college, courses in the College of Engineering that fall outside the jurisdiction of any one of the four Schools, and courses in the College of Arts and Sciences prescribed for students in engineering. Courses of instruction given by each of the four Schools of the College of Engineering are described under the appropriate heading.

ENGINEERING

1J31, 1J32. *ENGINEERING JOURNALISM.* Elective for Juniors who are members of the staff of *The Cornell Engineer.* Enrollment for credit must be with the approval of the class adviser. Throughout the year. Credit, two hours. Practical training in magazine editing and business management, including the writing of technical articles, copy reading, proof reading, makeup, and other editorial procedures; also accounting, advertising, the handling of circulation problems, and other phases of business management as related to publishing. Group meetings and individual conferences at hours to be arranged. Associate Professor THATCHER and Mr. SAMPSON.

1J41, 1J42. *ENGINEERING JOURNALISM.* A continuation of 1J31, 1J32. Elective for Seniors who are members of the staff of *The Cornell Engineer.* Enrollment for credit must be with the approval of the class adviser. Throughout the year. Credit, two hours.

GENERAL UNIVERSITY COURSES

HYGIENE

1. *HEALTH PROBLEMS, PERSONAL AND COMMUNITY.* Two terms. Credit three hours a term. Open to all students, preferably those above the freshman year.

A course designed to give the scientific principles underlying sound personal and community practices.

3. *HEALTH SUPERVISION OF SCHOOL CHILDREN.* Two terms. Credit three hours a term. Open to juniors and seniors. Prerequisite, suggested but not demanded, Health Problems, Personal and Community.

A practical course of lectures and demonstrations designed to familiarize the student with the facts and methods necessary for making an effective health supervision of school children.

4. *ADVANCED FIRST AID.* Two terms. Credit two hours a term. Enrollment limited, and registration only after conference with the professor in charge.

This course includes the theory of the diagnosis and temporary treatment of the common emergencies with practical application of the essential fundamentals.

8. *MENTAL HYGIENE.* Two terms. Credit three hours a term.

The relationship of the structure of the total personality to environmental maladjustment as evidenced by physical and social behavior; a discussion of the more common personality difficulties and the role of insight in the prevention of these.

MILITARY SCIENCE AND TACTICS

1. *BASIC COURSE.* Required. Throughout the year. The complete course covers

two years. Three hours a week, including one morning period of one hour and one afternoon period of two consecutive hours. Barton Hall.

The course of training is that prescribed by the War Department for Senior Division Units of the Reserve Officers Training Corps for basic students. The Basic Course comprises the instruction required for the Basic Training common to all arms and services of the Army. Further details concerning the course may be obtained at Barton Hall.

Required of all able-bodied first-year and second-year male students who are American citizens and candidates for a baccalaureate degree. The requirements of Military Science and Tactics must be completed in the early terms of residence; otherwise, the student will not be permitted to register again in the University without the consent of the faculty.

2. *ADVANCED COURSE.* Elective. Throughout the year. The complete course covers two years. Five hours a week. Credit 3 hours a term. Barton Hall.

Students who have completed the Basic Course, or who have had one year of service with any of the armed forces, are eligible for enrollment. Six months of service with the armed forces credits student with one year of the Basic Course for Advanced R.O.T.C. requirements.

The instruction is given in four of the arms and services, and includes Field Artillery, Ordnance, Signal Corps, and Quartermaster Corps, and requires the attendance at one summer camp for a six weeks' period. Completion of the Advanced Course qualifies the student for a commission as a 2nd Lieutenant in the Officers Reserve Corps U.S. Army. During this course, the student receives approximately $430 from the government and a regulation officer's uniform issued shortly after registration.

NAVAL SCIENCE

The Navy has established a unit of the Naval Reserve Officers Training Corps under the command of a Naval officer. Several courses in Naval Science are being offered in this department for which some credit is given toward an engineering degree. Students in the N.R.O.T.C. may substitute work done for University requirements in Military Science. For information concerning entrance to this unit and courses given, see the University's *General Information* booklet.

CHEMISTRY

102a, 102b. *GENERAL CHEMISTRY.* Throughout the year. Credit three hours a term. Chemistry 102a is prerequisite to Chemistry 102b. Open only to those students who have not offered high school chemistry for entrance. Lectures, M F 3 or T Th 8. Laboratory, M T W Th or F 8–11, 10–1, or 1:40–4:30, or S 8–11. Conference, one hour a week to be arranged. Mr. WOOD and assistants.

This course gives an introduction to chemistry, with emphasis on the fundamental concepts and principles which deal with the nature of matter and its behavior. The states of matter, the quantitative aspects of chemical changes, chemical equilibrium, oxidation-reduction, electrolytic dissociation, and solution phenomena are discussed. The structure of atoms is correlated with their properties, their classification, and the nature of their compounds. The more common elements and compounds are considered, and organic chemistry is studied briefly. The application of the scientific method is stressed, and abundant lecture demonstrations supplement the experience which the student acquires in the laboratory.

102b. *GENERAL CHEMISTRY.* Fall term. Credit three hours. Prerequisite, Chemistry 102a, 104a, or the first half of a satisfactory course in General Chemistry.

Lectures, M F 10 or 12. Laboratory, M T W Th or F 1:40–4:30, or S 8–11. Conference, one hour a week to be arranged. Mr. WOOD and assistants.

For description see Chemistry 102a, 102b.

104a, 104b. *GENERAL CHEMISTRY.* Throughout the year. Credit three hours a term. Chemistry 104a is prerequisite to Chemistry 104b. Open to those students who have offered high school chemistry for entrance. Lectures, T Th 10, 12, or 3. Laboratory, M T W Th or F 8–11, 10–1, or 1:40–4:30, or S 8–11. Conference, one hour a week to be arranged. Mr. VAN ARTSDALEN and assistants.

For description see Chemistry 102a, 102b.

For description of other courses in Chemistry required in the Chemical Engineering curricula, see page 121 of this Announcement.

ECONOMICS

3. *INTRODUCTION TO ECONOMICS.* Fall term. Repeated in the spring term. For students in Engineering. Credit three hours. M W F 8, 9, 11, 1, or 3; T Th S 8 or 9.

An introduction to the more essential economic features of contemporary American society.

11. *MONEY, CURRENCY, AND CREDIT.* Fall term. Credit three hours. M W F 9 or 11. Mr. REED.

An introductory study of the history and theory of money, currency, and bank credit.

31. *CORPORATION FINANCE.* Spring term. Credit three hours. Prerequisite, Economics 21a or its equivalent. M W F 9. Mr. O'LEARY.

A study of the financial practices of business corporations in the United States; types of corporate securities; sources of capital funds; determination and administration of corporate incomes; financial difficulties and corporate reorganizations; the relation of corporate practices to the functioning of the American economic system; and the regulatory activities of the Securities and Exchange Commission.

ENGLISH

2a, 2b. *INTRODUCTORY COURSE IN READING AND WRITING.* Throughout the year. Credit three hours a term. Both English 2a and 2b will be offered in each term, but 2a is a prerequisite of 2b. M W F 8, 9, 10, 11, 12, 1, 2, or 3; T Th S 8, 9, 10, 11, or 12. Mr. SALE and others.

The aim of this course is to increase the student's ability to communicate his own thought and to understand the thought of others.

GEOLOGY

501. *ENGINEERING GEOLOGY.* Fall term. Repeated in the spring term. Credit three hours only. Students who have had Geology A or 100 may take 501 for one hour credit. Lectures, M W 11. Laboratory, M W or T Th 2–4:30. Mr. ANDERSON.

The practical application of geologic principles to engineering work, and a study of the properties and occurrence of such mineral and rock materials as are of importance to engineering students. The purpose of the course is to provide a geologic background so that the engineer will be competent to adapt his work to conform with the limitations imposed by geologic conditions.

HISTORY

70. *SCIENCE IN MODERN CIVILIZATION.* Fall term. Credit three hours a term. Primarily for students in the College of Engineering. Not open to freshmen. M W F 11. Mr. GUERLAC.

MATHEMATICS

55a, 55b. *ANALYTIC GEOMETRY AND CALCULUS.* Throughout the year. Credit five hours a term. Primarily for students in the College of Engineering; the prerequisites for such students are Mathematics 15, and Mathematics 5 or 10, or the equivalent. For students in the College of Arts and Sciences, the prerequisites for Mathematics 55a are the same as those stated for Mathematics 60a. M T W Th F 11 or 1.

60a, 60b, 60c. *ANALYTIC GEOMETRY AND CALCULUS.* Three terms; each course is offered each term. Credit three hours a term. For students in the College of Engineering, the prerequisites are Mathematics 15 and Mathematics 5 or 10, or the equivalent. For students in the College of Arts and Sciences, the prerequisites are Mathematics 15 or the equivalent, and a thorough preparation in Intermediate Algebra. Students without thorough preparation in Intermediate Algebra are advised to take Mathematics 10 before taking Mathematics 60a. Mathematics 10 may be taken simultaneously with Mathematics 60a. Some students interested in mathematics or allied subjects will be expected to take 60a, 60b, 60c. Fall or spring term — Mathematics 60a: M W F 9 or 12; T Th S 9 or 11. Mathematics 60b: M W F 8 or 9; T Th S 11. Mathematics 60c: M W F 8, 9, or 12; T Th S 9.

200. *ELEMENTARY DIFFERENTIAL EQUATIONS.* Fall term. Repeated in the spring term. Credit three hours. Prerequisite, Mathematics 60c or the equivalent. T Th S 10 or 12.

215. *ADVANCED CALCULUS.* Throughout the year. Credit three hours a term. Prerequisite, Mathematics 60c or the equivalent. M W F 11.

A careful study of limits, continuity, derivatives, and Riemann integrals. Functions of several variables. Multiple and line integrals. The course is designed to furnish necessary preparation for advanced work in analysis and applied mathematics.

480. *DIFFERENTIAL EQUATIONS OF MATHEMATICAL PHYSICS.* Throughout the year. Credit three hours a term. Prerequisite, Mathematics 215. M W F 11.

The derivation of the differential equations, with appropriate boundary conditions, which arise in certain problems of mathematical physics; the mathematical properties of solutions, and the physical meanings of these properties.

PHYSICS

15. *MECHANICS.* Fall term. Credit three hours. Prerequisite, Calculus or simultaneous registration in Mathematics 55a or 60a. Entrance physics is desirable but not required. Lectures, W 9 or 11. Recitations, M F 9. Laboratory, M 2–4:30. Messrs. GRANTHAM, NEWHALL, and assistants.

Demonstrations, theory, problem drill, and experiments covering kinetics, statics, elasticity, liquids, and mechanics of gases.

16. *WAVE MOTION, SOUND, AND HEAT.* Spring term. Credit three hours. Prerequisite, Physics 15 and Calculus, or simultaneous registration in Mathematics 55b or 60b. Lecture, W 9 or 11. Two recitations and one laboratory period a week to be arranged. Messrs. GRANTHAM, NEWHALL, and assistants.

Demonstrations, theory, problem drill, and experiments covering wave types, wave motion, sound production and reception, acoustic measurements, temperature measurement, calorimetry, changes of state, liquefaction of gases, thermal behavior of gases, heat transfer, and elementary thermodynamics.

17. *GENERAL PHYSICS.* Fall term. Credit three hours. One lecture, two recitations, and one laboratory period a week. Prerequisite, Physics 5b, Calculus or simultaneous registration in Mathematics 60c. Demonstrations, theory, experiments and problems on electric charges, electric field, electrical potential, electrical charges in motion, the electric current, magnetic and electrolytic effects of current, electromotive force, electrical resistance, the electric circuit, Ohm's law, Kirchhoff's laws, electrical energy and power, electro-magnetism, induced emf, capacitance, measurement of magnet flux.

18. *GENERAL PHYSICS.* Spring term. Credit three hours. One lecture, two recitations, and one laboratory period a week. Prerequisite, Physics 6a, Calculus. Demonstrations, theory, experiments and problems on mutual inductance, self-inductance, growth and decay of current in inductive circuits, energy of magnetic fields, magnetic substances, current in a resistance-capacitance circuit. Energy of a charged condenser, energy of an electric field, sinusoidal emf series, alternating-current circuit, thermoelectricity, thermionics, gaseous discharge, the photoelectric cell, fundamental light principles, photometry, reflection, refraction, lenses, optical instruments, dispersion, spectra, color, spectral series, resonance and ionization potentials, diffraction and interference, double refraction and polarization, radiation, atomic structure, nuclear physics.

21. *ELECTRICITY AND MAGNETISM.* Fall term. Repeated in the spring term. Credit three hours. Prerequisites, Physics 11 and 12 and Mathematics 60c or 65c (or either in parallel). Required of candidates for degrees of B. Chem. E., B.E.E., and B.M.E. Recitations, T Th 8. Laboratory, F 2–4:30. Mr. TOMBOULIAN and assistants.

22. *OPTICS AND ELECTRONICS.* Fall term. Repeated in the spring term. Credit three hours. Prerequisites, same as for Physics 21. Required of candidates for degrees of B. Chem. E., B.E.E., and B.M.E. Recitations, T Th 9. Laboratory, Th 2–4:30. Mr. TOMBOULIAN and assistants.

44. *MODERN PHYSICS.* Required in Electrical Engineering. Term 8. Credit three hours. Three lectures each week. Prerequisite, Physics 15, 16, 17, 18, and 4031. Text: *Modern Physics,* JAUNCEY. The fundamental particles of physics, the structure of atoms and molecules are considered from the quantum-mechanical point of view. The electrical conductivity of gases and solids is studied.

65. *MECHANICS AND PROPERTIES OF MATTER.* Fall term. Credit three hours. Prerequisites, Physics 3 and 4, or 7 and 8, and (or in parallel) Integral Calculus. M W F 8. Mr. CORSON.

Linear and plane kinematics of a mass point, Newton's laws, linear plane dynamics, work and energy, simple harmonic motion, dynamics of a system of particles, statics and dynamics of rigid bodies, hydrostatics, fluid dynamics, elasticity, and wave motion and sound.

105. *ADVANCED LABORATORY.* Fall term. Repeated in the spring term. Credit three hours. Prerequisites, Physics 60, 63, 64, and 65, or their equivalents. Laboratory, T W Th or F 1:40–4:30 (two periods required). One discussion period to be arranged. Mr. COLLINS and Mr. PARRATT.

Experimental work in a wide variety of fields is offered to meet the needs of the individual student. Considerable time may be spent on a relatively few topics, or many experiments may be performed to gain acquaintance in several fields. The

laboratory work is individual, and stress is laid on independent work on the part of the student. Among the topics for which facilities are available are mechanics, acoustics, optics, spectroscopy, electrical circuits, electronics and ionics, heat and temperature measurements, x-rays.

111. *ANALYTICAL MECHANICS.* Fall term. Credit three hours. Prerequisites, Physics 65 and Differential Equations. M W F 9. Mr. SPROULL.

Analytical mechanics of material particles, system of particles and rigid bodies; Lagrange's equations; oscillations, forced vibrations.

123. *ELECTRICITY AND MAGNETISM.* Fall term. Credit three hours. Prerequisites, Physics 21 or Calculus, and (or in parallel) Physics 63. T Th S 9. Mr. MURDOCK.

Electrostatic and electromagnetic fields, polarization of dielectrics and magnetic media, displacement current, plane electromagnetic waves, the Poynting vector.

124. *ELECTRICITY AND MAGNETISM.* Spring term. Credit five hours. Prerequisites, Physics 123 and Differential Equations. Lectures, T Th S 9, and two laboratory periods to be arranged. Mr. TOMBOULIAN.

General circuit theory from the standpoint of fields, steady current circuits, nonsteady current circuits, alternating current circuits, steady current networks, alternating current networks, frequency characteristics of networks, filter circuits and lines.

135. *OPTICS.* Fall term. Credit five hours. Prerequisites, Physics 60, 65, and the Calculus. Lectures, M W F 8. Laboratory, T W or Th F 1:40–4:30. Mr. COLLINS.

Geometrical optics, lens systems, Gauss points, aberrations, stops, photometry of optical systems, interference, application of various forms of interferometers; Fresnel and Fraunhofer diffraction patterns and their applications to optical instruments; polarized light, production, detection, measurements and applications of plane and elliptically polarized light.

165. *WAVE MOTION AND SOUND.* Spring term. Credit five hours. Prerequisites, Physics 111 or its equivalent; Physics 124 is desirable. Lectures, M W F 8. Laboratory, T W or Th F 1:40–4:30. Mr. COLLINS.

Elasticity, hydrodynamics, vibrations of mechanical systems, propagation of mechanical waves, mechanical and acoustic impedance, characteristics of sound sources and receivers, sound intensity measurements, and simple acoustic filters.

173. *ATOMIC AND MOLECULAR PHYSICS.* Fall term. Credit three hours. Prerequisite, Physics 123. T Th S 9. Mr. MORRISON.

The fundamental particles; classical and quantum mechanical concepts; atomic structure; interaction between atoms and radiation; molecular structure; collision phenomena; fundamentals of nuclear physics.

174. *ELECTRONIC PROPERTIES OF SOLIDS AND LIQUIDS.* Spring term. Credit five hours. Prerequisite, Physics 173. Lectures, T Th S 9. Two laboratory periods as arranged.

Lattice structure of solids; magnetic, dielectric, and thermal properties of solids; electrical and optical properties of metals, semi-conductors and ionic crystals; electron emission and barrier layer effect; relaxation phenomena in liquids and solids.

320. *SPECIAL TOPICS LABORATORY.* Prerequisites, Physics 105 or its equivalent, and consent of the instructor. Hours to be arranged.

Systematic laboratory work together with appropriate lectures and discussions will be offered in the following fields:

(a) *NUCLEAR PHYSICS.* Fall term. Repeated in the spring term. Credit two hours. Mr. McDANIEL and Mr. DEWIRE.

[(b) *SPECTROSCOPY.* Credit two hours. Not offered in 1946–1947.]

(c) *X-RAYS.* Fall term. Credit two or three hours. Mr. PARRATT.

(d) *ELECTRONICS AND IONICS.* Fall term. Credit two or three hours. Mr. SPROULL.

(e) *CRYSTAL STRUCTURE BY X-RAY AND ELECTRON DIFFRACTION.* Spring term. Credit two hours.

[(f) *HIGH TEMPERATURE MEASUREMENTS.* Credit two hours. Not offered in 1946–1947.]

405. *MATHEMATICAL METHODS IN PHYSICS.* Throughout the year. Credit three hours a term. Prerequisites, Mathematics 60c or its equivalent, and at least two years of general physics. M W F 12. Mr. FEYNMAN.

PUBLIC SPEAKING

1. *PUBLIC SPEAKING.* Fall term. Repeated in the spring term. Credit three hours. Not open to freshmen. M W F 8, 9, 10, 11, 12, 2, or 3; T Th S 8, 9, 10, or 11. Messrs. WAGNER, WICHELNS, ARNOLD, DEBOER, and assistants.

The fundamentals of speech; emphasis on speech preparation and on direct, communicative delivery. Study of principles; constant practice; conferences.

Foreign students and others whose pronunciation of English falls below the normal standard, and students with special vocal problems, are advised to confer with Mr. THOMAS before registering.

PSYCHOLOGY

40. *PSYCHOLOGY FOR ENGINEERING STUDENTS.* Fall term. Credit three hours. Open by permission to students in Arts and Sciences. M W F 2. Mr. RYAN.

A survey of basic facts and principles of psychology and their application.

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The issues of this publication are designed to give prospective students and other persons information about Cornell University. No charge is made except for the *Directory of Staff and Students* and *A Book of Pictures.*

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